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THESIS

PRIVATIZATION OF WATER IN GOVERNMENT OWNED HOUSING: A FORECASTING MODEL

by

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This thesis examines the option of privatizing water utilities, requiring residents of Government Owned Housing (GOH) to pay for all consumption. To assist in the payment, a Water Allowance (WA) would be provided to residents based on the average consumption of local Private Sector Housing (PSH) residents. The goal of this thesis is to determine if implementing a WA would reduce the overall water consumption in GOH. Specifically, it determines the historical usage of water in the Naval Postgraduate School's La Mesa Housing Village (LMV) area and the local PSH areas. It then develops forecasting models for both areas to predict the future consumption of water, sets a baseline consumption rate for LMV residents, and identifies the savings that would be generated from implementing the WA program. After validating the forecasting models and comparing costs under the WA concept, this study concludes that the WA concept would save approximately $18,355 annually at LMV alone. Although, the WA concept does not meet the Navy's goal of identifying and implementing by 2005 all life cycle cost-effective water conservation measures with a payback period of less than 10 years, it does recoup the initial metering cost of $237,200 in 12.7 years. By implementing a WA concept, the projected savings in LMV alone are approximately 6.1% per person per day. Although the study focuses on LMV, it is assumed that similar water consumption inefficiencies are being demonstrated in other GOH areas.

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PRIVATIZATION OF WATER IN GOVERNMENT OWNED HOUSING: A FORECASTING MODEL

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ABSTRACT

This thesis examines the option of privatizing water utilities, requiring residents of Government Owned Housing (GOH) to pay for all consumption. To assist in the payment, a Water Allowance (WA) would be provided to residents based on the average consumption of local Private Sector Housing (PSH) residents. The goal of this thesis is to determine if implementing a WA would reduce the overall water consumption in GOH. Specifically, it determines the historical usage of water in the Naval Postgraduate School's La Mesa Housing Village (LMV) area and the local PSH areas. It then develops forecasting models for both areas to predict the future consumption of water, sets a baseline consumption rate for LMV residents, and identifies the savings that would be generated from implementing the WA program.

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I. INTRODUCTION

A. PROBLEM BACKGROUND

The Office of the Chief of Naval Operations Instruction (OPNAVINST) 5090.1B requires that the Commanding Officers of shore activities "review the various uses of water at their activities to ensure that all economically practical water conservation measures are taken." Executive Order 12902, "Water and Water Efficiency in Federal Facilities," further directs agencies to identify conservation opportunities and install cost-effective conservation measures. Additionally, the Federal Water Policy Act of 1992 (EPAct) established national water efficiency standards for plumbing fixtures and equipment. The Federal Water Management Program (FEMP) and the Department of the Navy have a defined water conservation strategy to reduce costs and usage. Specifically, three major program goals are to:

- Ensure that water at any activity is being used appropriately and efficiently, to minimize water waste, and to identify a yearly target reduction volume.
- Ensure the Federal Water Management Program includes conservation education, awareness and support.
- Implement, to the maximum extent possible, the Water Policy Act of 1992 which requires Federal agencies to identify and implement by 2005, all life cycle cost-effective water conservation measures with a payback period of less than 10 years(Federal Water Management Program (FEMP) "Focus" 1997, p. 1).

In view of these goals, the Navy must aggressively look at all water users.[1] Some users that could provide significant water savings are the residents of Government Owned Housing (GOH).

In the South Western Division of the Naval Facilities Engineering Command, (all of the West Coast, including San Diego and Monterey), the Navy manages approximately 12,000 GOH units (Naval Facilities Engineering

[1] A "user" is defined as any organization or individual that uses water.

Command, Southwest Division, 1997, p. 1). Because the Navy pays all water-related bills, there are generally no individual monitoring devices or programs to provide incentives for residents of these housing areas to reduce water consumption.

Because there are not any individual monitoring devices and no way to pinpoint which, if any, resident is wasting water, residents of GOH have no incentives to reduce overall water consumption and can, essentially, use as much water as they desire.[2] In private sector housing (PSH), residents can also use as much water as they desire. However, there is an incentive for these individuals to reduce their overall water consumption. Since PSH residents must pay for all water consumed, given that as consumption increases costs increase, most will employ a water reduction program to reduce overall water costs to a level that they can afford.

This thesis examines the potential savings that could be achieved by creating incentives for residents of GOH to reduce overall water consumption. It will focus on potential water savings that could be achieved by paying residents of GOH a forecasted amount (based on PSH consumption) to pay water bills directly to the water provider. Once residents of GOH are given a fixed dollar amount for water usage, they will have essentially one of two options:

- Pay additional costs (out of pocket) for going over the predetermined amount.
- Reduce overall water consumption to either break-even or gain monetarily from benefits of reduction.

Although residents of GOH forfeit all housing allowances once they move in, a Water Allowance (WA) could be generated from a forecasting model to create an incentive to reduce overall water consumption. The forecasted allowance would be based on the average consumption used by local PSH residents. The

[2]Navy water conservation programs do exist for GOH residents, however these programs are in the form of "water conservation awareness" vice water conservation compliance. Additionally, often these programs are only administered by posting bulletins and passing information in the local housing flyers. Only 1 water meter is installed for the entire 877 units at the LaMesa Village Housing area Monterey, CA. There is no way to determine who is complying and who is not complying with the overall water conservation program.

forecasting model examines the water consumption behavior of PSH residents and then compares it to the consumption pattern of GOH residents.

Specifically, the model addresses consumption patterns of Naval Postgraduate School (NPS) GOH residents and PSH residents in the same geographical area- Monterey, California. The thesis provides steps to implement similar models in other Navy housing areas.

B. SPECIFIC FACTORS WITH RESPECT TO WATER USAGE

Though the primary scope of this study focuses on usage, certain cost factors that complicate implementation of an incentive plan must be discussed. These include the following factors:

1. Multiple Water Rate Structures

California-American Water Company, Monterey Division (CAL-AM) charges multiple rates for its various residential customers depending on geographical location. There are three residential rates that CAL-AM charges its customers, based on the type of service that is provided, to the Monterey Peninsula area. NPS is charged under one of these rates, while a majority of PSH residents (in the Monterey area) are charged under the other two rates. The three rate schedules are summarized below:

2. Special Water Schedule for La Mesa Housing

La Mesa housing complex is charged a negotiated contract price for water usage. This fee is a combination of meter rates and usage rates. The monthly charge for service under this contract is the sum of meter charges and total water consumed (Schedule No. Mo-1 1997, p.1):

- The meter charge is a flat monthly fee per meter
- There is a flat fee per 100 cubic feet[3] of water delivered. It is charged at the rate of $2.3805 per 100 cubic feet per meter, per month.

3. Apartments and Multi-Family Master Metered Category

This schedule includes water services supplied to multifamily accommodations through one master meter where all the accommodations are not

[3]100 cubic feet of water is equal to 748.05 gallons of water. Data that is provided by CAL-AM is usually measured in acre-feet. (1 Acre foot=325,872 gallons).

separately sub-metered. Water charges under this schedule are broken down as follows:

- For every 100 cubic feet of water delivered the charged is $1.7854 per meter, per month.
- In 1st elevation zone[4], for every 100 cubic feet of water delivered the charged is $1.8953 per meter, per month.
- In 2nd elevation zone, for every 100 cubic feet of water delivered the charged is $2.09525 per meter, per month.

4. Residential and Program for Alternative Rates (PAR) Service

Includes water services provided to single-family dwellings and to flats and apartments separately metered by CAL-AM. Charges include:

- For the first 800 Cubic feet of water delivered, the charge per 100 cubic feet of water is $2.6201, per meter, per month.
- For the next 800 Cubic feet of water delivered, the charge per 100 cubic feet of water is charged $3.2152, per meter, per month.
- For over 1600 Cubic feet of water delivered, the charge per 100 cubic feet of water is $5.5957, per meter, per month

In summary, water rates differ somewhat between GOH and PSH. These differences will become important when conducting a cost benefit analysis of creating an incentive system for GOH occupants. Assumptions about future rate schedules must be speculated.

C. THESIS OBJECTIVES AND METHODOLOGY

The Navy goal of ensuring that all economically practical water conservation measures are taken requires adherence to national and local water conservation measures and incentives to reduce water consumption. In today's environment of a declining Defense Budget, it is critical that we spend every dollar wisely. This thesis proposes to shift some of the responsibility of conserving water from the Department of the Navy to the individual service member. Through the adoption of the proposed initiative the Department of the Navy could achieve

[4]Elevation zone is the level above sea level. The 1st zone is 200 feet above sea level. It requires one pumping station. The 2nd zone is 400-600 feet above sea level. It requires two pumping stations.

significant reductions in water related costs. This thesis will attempt to determine if any savings can be achieved by privatizing water utilities in GOH.

The first task was to sample PSH water consumption within the same geographical area to determine water consumption rates. The second task was to determine the water consumption rates for GOH. The third task was to analyze the data and draw some conclusions about historical usage between GOH and PSH. Data were drawn from actual GOH usage as well as data provided by CAL-AM for PSH. The data items were chosen to enable computation of predicted water usage. The fourth task was to develop a forecasting model based on statistical information. The model was developed to represent an accurate forecast of water usage. The fifth and final task was to analyze the forecasted water usage for PSH and if representative, then project any savings that could be generated by creating an incentive system for GOH residents.

D. RESEARCH QUESTIONS

Can the Department of the Navy generate any significant water and monetary savings by creating an incentive system for GOH residents? If so, what are the predictor variables that should be used and how should they be selected? What would be the cost of implementing monitoring programs and would such programs outweigh the potential savings generated?

E. GENERAL COMPLICATING FACTORS

Determination of water consumption patterns for individual GOH residents, as well as PSH residents, and forecasting a baseline usage rate for both are complicated due to a number of general factors. A discussion of these factors follows.

1. Individual GOH Units Are Not Metered

NPS has approximately 877 GOH units of various sizes.[5] There is a single master meter for all water consumed by these units. Therefore, it is impossible to precisely determine water consumption by each individual unit.

2. GOH Units and Lots Are Not the Same Size

NPS manages various units including single family, duplex, triplex, apartment, and townhouse dwellings. Because of this diversity in unit size and lot size, each home will consume different amounts of water.

[5]NPS GOH units vary in size from 811 square Feet to 1622 square feet.

3. Numbers of Occupants Vary in Individual GOH Units

Assignment of GOH is not dependent on size of individual families.[6] Consequently, the number of occupants in each household varies. It is intuitive to expect smaller families to consume less water. Also a smaller family will have a smaller lot therefore less yard to water.

4. Historical Data was not available before 1994 for PSH

It is difficult to determine monthly consumption of water for PSH due to unavailability of data before 1994. Vendor records were not available before 1994 for the city of Monterey.[7] This complicates the implementation of an accurate forecasting model for PSH due to comparison of only three years of data vice ten for GOH. To overcome this problem, estimates were based on three years of historical records. The data therefore are not as accurate as the GOH model but still can be used for comparison purposes.

5. There are Large Variations in PSH Sizes

In developing an accurate forecasting model, the average size PSH and lot must be determined in order to allow comparison to GOH. The Monterey Peninsula governmental agencies do not collect this statistical data. Information must be gathered from local Realtors who have historical sales records. In order to generate the average size of PSH, a representative sample of home sizes sold in the local area was computed.

6. GOH Lots and PSH Lots are not the same size nor do they have the same type of vegetation.

The difference in lot sizes and vegetation among GOH units is similar to the differences between GOH units and PSH units. The differences are not only in size of units, but also include type of construction, number of residents and location the type of vegetation. It is not feasible to accurately determine the size of lots, water efficiency, and number of occupants of each PSH unit in the local area. Assumptions and estimates from available data were used in determining a forecasting model.

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[6]To be assigned GOH, the occupant must be a member of the armed forces and married, or if an International Student just be married.

[7]Vendor in this situation refers to California America Water Company Monterey District (CAL-AM) the provider of water to La Mesa Housing Complex.

F. SCOPE

This study used water consumption data from the Naval Postgraduate School GOH and surrounding community to develop a forecasting model. This thesis also examined the necessary steps to implement the model in other Navy housing areas.

The main focus of this research was be to develop a forecasting model based on statistical analysis of the historical water usage data in both GOH and PSH for the past ten years.

It specifically investigated those variables that were required in the model to provide a realistic forecast. The thesis does not analyze the water usage rates or cost for any area other than NPS La Mesa Housing area. Additionally, it was beyond the scope of this thesis to determine exact water consumption of individual housing units. The intent of the thesis is to illustrate the inefficiencies of GOH residents water usage.

A summarization of the findings includes recommendations for potential solutions that could be implemented.

G. ASSUMPTIONS

Since it was not practical, given the scope and time limit of this thesis, to measure the efficiency of each housing unit in the sample area, it is assumed that on aggregate, units are alike. Comparison of water usage data is based on the premise that the aggregate home and lot in the PSH market is of like construction and quality to GOH. It was also assumed that the aggregate household size in PSH is 2.0 persons per unit (Census data for 1990) and for GOH there are 4.08 persons per unit (La Mesa Housing data). It also assumed that all water used for common areas and all day workers, such as PWC employees, was charged entirely to GOH residents. Additionally, only residential water usage amounts were used. All other users of water, including the La Mesa Village School and La Mesa Village Store were factored out. These amounts were factored out based on a historical average daily usage. The thesis only addresses average water consumption rates. It is not feasible to generate accurate individual usage rates for GOH because individual units are not metered. Additionally, determination of exact individual water consumption patterns in PSH would not be practical given the time limitations of this thesis.

H. RESEARCH SOURCES

Research for this thesis was conducted using primarily archival research at the Naval Postgraduate School and CAL-AM and investigative research at the La Mesa housing complex.

Actual water usage for LMV was provided by NPS Public Works Center (PWC) in the form of NAVCOMPT Form 2035 Summary of Accounting Data reports and CAL-AM monthly billing reports. CAL-AM reports are submitted for archiving to their Headquarters in San Diego, CA. The CAL-AM reports provide specific water usage each month for La Mesa Housing area and bi-monthly data for Monterey City. CAL-AM provided PSH data with a breakdown of water usage by city, number of customers, consumption per month, consumption per day per account and type of customer.[8] Other data used for the cost-benefits analysis was obtained through personal interviews with PWC engineers and PWC housing staff.

I. ORGANIZATION OF THE STUDY

The thesis is divided into five chapters including the introduction. Chapter II provides the water consumption review of GOH and PSH based on archival research. Chapter III provides the model selection and predictor variables used to compare and develop a forecast of future water consumption to generate an incentive system. Chapter IV presents the findings and analysis from this study. Chapter V provides a brief summary, conclusions and lessons learned from this thesis.

[8]Type of customer refers to single family residents and multiple family dwellings with individual meters. Both of these categories fall under CAL-AM Residential and Program for Alternative Schedules.

II. ARCHIVAL DATA REVIEW

A. BACKGROUND

1. La Mesa Village

The Navy manages 877 GOH units in the La Mesa Village Housing (LMV) area. Normally, all units are reserved for the use of students and active duty officers assigned to NPS.[9] Historically, occupancy rates at LMV have varied from 68% to 86% per month with the average occupancy rate at 76.49% per month. The key factors that affect overall occupancy rates are size of the reporting class and number of unit out or service for upgrades and maintenance. Figure 2.1 illustrates the occupancy rates at LMV (Naval Postgraduate School, 1997, p. 1).

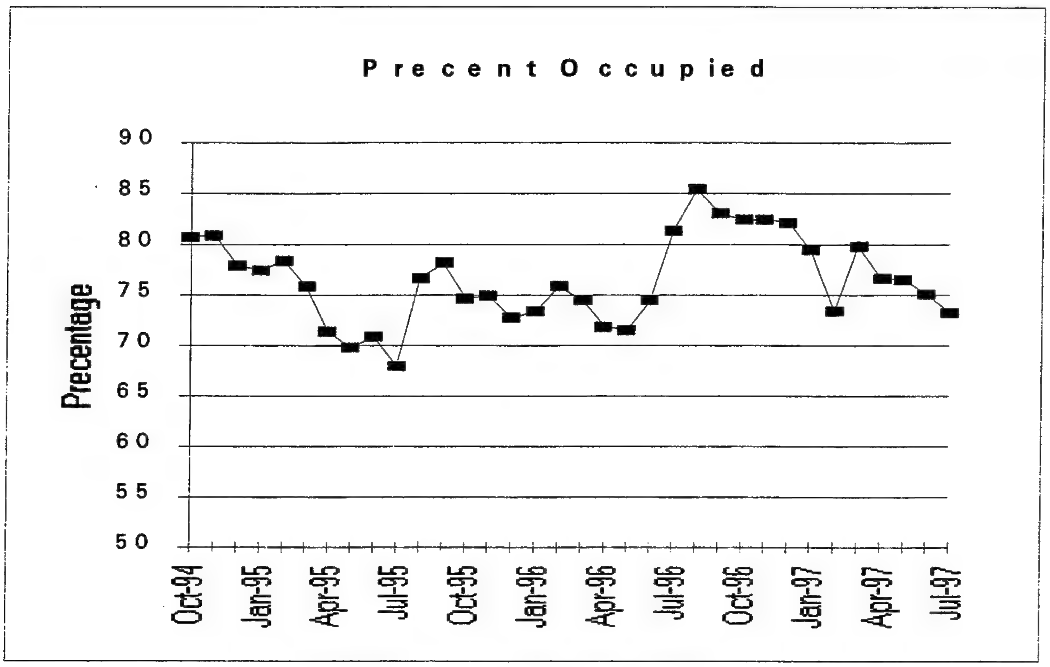


Figure 2.1. Percent Occupied

2. Requirements of Occupancy at LMV

Upon accepting assignment to GOH, a service member agrees to forfeit all housing allowance, in return, the member is assigned housing at no cost. The

[9] NPS also manages the Presidio of Monterey Annex housing complex. This area is reserved for eligible enlisted member, Defense Language Institute students, and NPS students, including International students, who could not be assigned in La Mesa.

Navy pays for all utilities, including water usage, and all related maintenance during occupancy. These benefits are funded under the Family Housing, Navy and Marine Corps (FH, N&MC) appropriation. The FH, N&MC appropriation is composed of two categories, Construction and Operations & Maintenance (O&MN). The O&MN part of the appropriation provides funding for the cost of housing management, appliances, services, leasing, repairs and utilities (Autrey, 1996, p. 12).

The amount of water consumed will generally differ from each household depending on the size of the unit, size of the lot associated with the unit, and the number of occupants per unit. Housing at LMV is assigned based on a person's rank and number of dependents. Field Grade Officers[10] and service members with large families received larger quarters with more bedrooms, more overall square feet, and usually a larger lot size. The exact demographic make up of LMV is beyond the scope of this thesis, however, to be able to compare GOH data to PSH data, all data were converted to per person per day consumption. Therefore, the average occupancy rate and the average number of tenants per day were computed from historical data. The average number of tenants per day ranged from a high of 3026 to a low of 2262 with the average at 2672. The average number of tenants along with the occupancy rate of 76.49 % was used to find the average number of persons using water each day for the LMV. Figure 2.2 illustrates the average number of tenants for LMV(Naval Postgraduate School, 1997, p. 1).

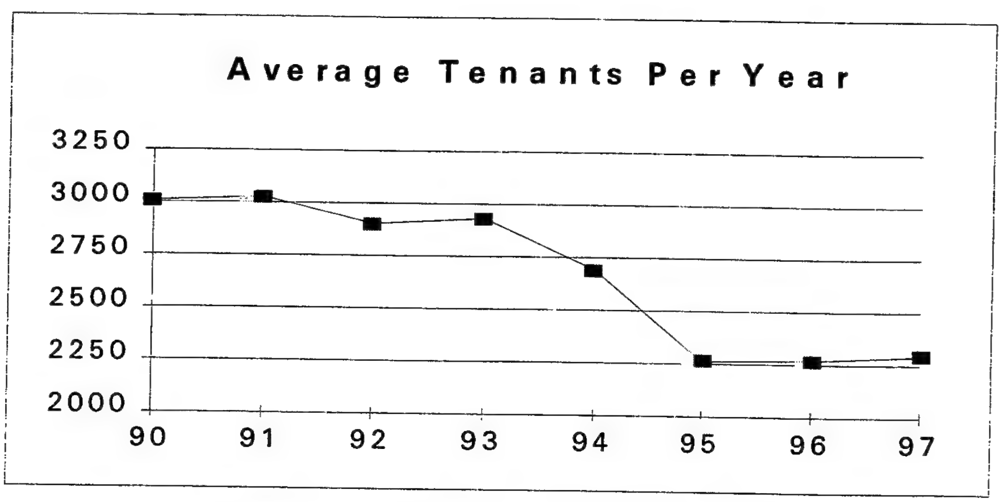


Figure 2.2. Average Tenants Per Year

[10]Field Grade Officer generally refers to O-4s and O-5s.

3. Water Consumption at LMV

CAL-AM is the sole provider of water at LMV. A single master meter for the water delivered is used to assess the amount of water consumed by the LMV residents. As noted in chapter one, CAL-AM charges a negotiated price for the water usage. CAL-AM sends a summary and detailed water bill to the NPS Comptroller's Officer for payment. This bill is then forwarded to the LMV housing office and PWC Department where it is reviewed and payment authorized.

4. Navy Water Conservation Programs

Naval Facilities Engineering Command (NAVFAC), as the facilities expert, issues all direction and guidance related to water conservation matters (Naval Facilities Engineering Command, 1988. p. 1). NPS has established an Energy/Resource Conservation Committee to educate personnel, identify energy and resource conservation projects, assess the progress toward conservation goals and to report on the recommendations of action to conserve resources. The committee is primarily composed of the Commanding Officer, the Public Works Officer, and Energy/Resource Conservation Coordinator, and PWC civilian engineers. In supporting the committee's goals the Energy/Resource Conservation Committee conducts an annual Energy/Resource Conservation Week. This is the only program that targets LMV residents. During this week, pamphlets, posters and flyers are placed at various locations in the command. Because the information is not sent directly to every individual, the assumption is that not all residents receive or review all the information. Also, since there is only one water meter for the entire LMV complex, it is impossible to provide feedback to those residents who are complying with water conservation measures.

According to the Congressional Budget Office, utility costs drop by 20% when residents become responsible for their own usage(Autrey, 1996, p. 14). This thesis makes the assumption that LMV residents, as a whole, are not aware of water usage because they do not pay any of the costs.

B. WATER CONSUMPTION REVIEW OF LMV

1. Introduction

This section examines the consumption rate of water for LMV residents and allows a comparison to PSH residents for Monterey, California. Specifically, consumption is compared on a per person per day basis. Since it was not possible to determine the exact usage of individual residents, an average consumption rate

per day was used. Also, since the data consisted of chronologically arranged observations of water consumption, it was consistent with time series data. The underlying assumption of time series is that there exists a pattern, which is a function of time. This data can be broken down or decomposed into subpatterns that reflect the different groups of forces that influence the value of the series (Liao, 1997, pp.1-2):

- Long Term Trend: The trend represents the long-term behavior of the data, and can be increasing, decreasing or unchanged.
- Seasonal Variation: A time series is said to exhibit a seasonal pattern if the value of the variable changes according to the seasonal regularity. It reflects periodic fluctuations of constant length in time.
- Cyclical Variation: A behavior with no distinct upward or downward long-term trend with time. The distinction between seasonality and cyclicality is that seasonality repeats itself at fixed intervals such as a year or month, while cyclical factors have a longer duration that varies from cycle to cycle.
- Random Deviation: There is no discernible pattern whatsoever to the time series. It wanders about some average value in a random way. This element of error or randomness is always present in a typical time series.

2. Actual Water Consumption for LMV

Figure 2.3 shows the actual water consumption per person assigned for LMV from 1987 to 1997. The long-term trend suggests that water consumption is fairly consistent from one year to the next with maximum consumption remaining below 210 gallons of water per person per day. There seems to be a slight downward trend of overall water consumption since 1987. This perhaps can be contributed to the drought of 1989 through 1992 and to education of residents about water conservation. However, since individual units are not monitored for consumption, it is hard to determine the actual cause. By looking at the data in Figure 2.3, a seasonal variation is noted with the highest consumption occurring in the month of August and the lowest consumption occurring in the month of February. The values differ from year to year, but the differences can be attributed to random variation of the data. The data do not suggest that there are any cyclical variations.

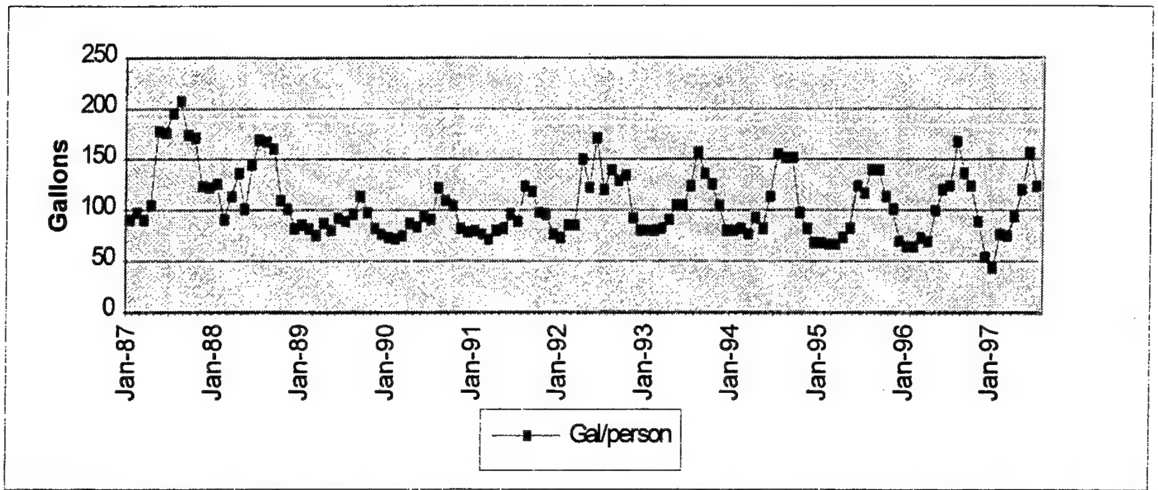


Figure 2.3 La Mesa Water Consumption Per Person Per Day

C. WATER CONSUMPTION REVIEW OF PSH

1. Introduction

As stated in the Navy's Energy Management Plan (NEMP), "**Restrictions shall not be levied on Navy family housing, which would reduce quality of life below that normally available to families in the civilian community**"(Autrey, 1994, p. 18). The NEMP also includes water conservation methods. Investigation of PSH water consumption was conducted to esure GOH complied with NEMP guidelines.

In order to develop a forecasting model to apply to GOH residents, consumption data for the local Monterey, California area were analyzed. Since La Mesa Village is located within the city of Monterey; Monterey City was chosen to provide PSH data. CAL-AM provided the number of customers and amount of water consumption per account.

2. Actual Water Consumption for Monterey City

A review of Monterey City's water consumption was limited to three years; 1994 though 1996. The data were also presented in a bi-monthly format. This amount of data was adequate to provide a comparison baseline for LMV. The data suggest that the residents of Monterey City follow very closely the long term trend noted in LMV data. However, while the long-term trend for LMV was slightly

decreasing, the long-term trend for Monterey City suggests a slightly increasing trend. Figure 2.4 illustrates the water consumption per person per day for Monterey City.

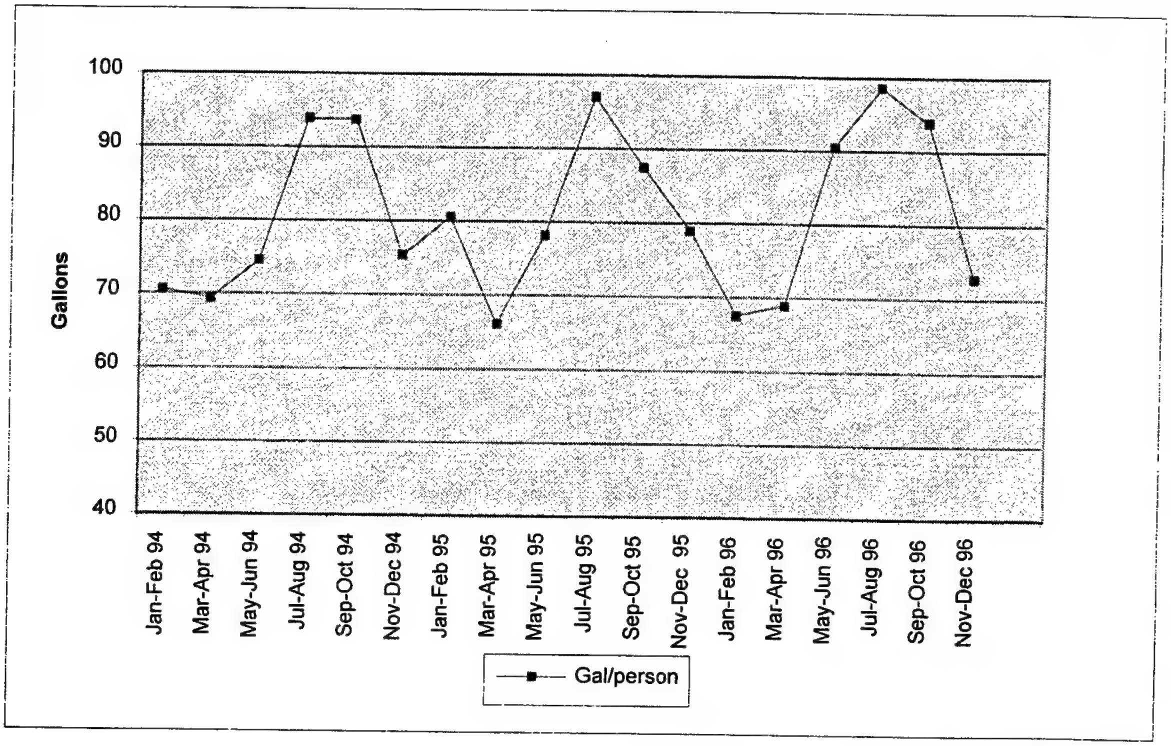


Figure 2.4 Monterey City Water Consumption Per Person Per Day

By examining the data in Figure 2.4, a definite seasonal variation is noted with the time series data with the highest consumption occurring in the months of July and August and the lowest consumption occurring in the months of March and April. The seasonal patterns observed occur at approximately the same periods during the year. The values differ from year to year, but the differences can be attributed to random variation of the data. The data do not suggest that there are any cyclical variations.

D. LMV VERSUS PSH WATER CONSUMPTION

1. Introduction

This section provides a comparison of water usage per person per day between LMV and PSH. All data were provided by CAL-AM water reports and NPS Public Works Center NAVCOMPT Form 2035 Summary of Accounting Data reports. The number of LMV residents was computed as discussed in Chapter 1.

The number of residents per water account was computed by using the 1990 census data for Monterey City.

2. LMV and PSH Water Consumption Comparison

As previously discussed, both LMV and PSH time series data are seasonal in nature and show no cyclical variation. Long-term trends that were identified in the water consumption are probably correlated to the same variable. Additionally, random deviation in the data cannot be identified with a common variable. Figure 2.5 shows the comparison between LMV and PSH water consumption. All the data presented are per person per day to allow ease of comparison. LMV data show more random deviation that PSH. It is also apparent, from Figure 2.5 that LMV residents, on the average, consume more water than their private sector counterparts.

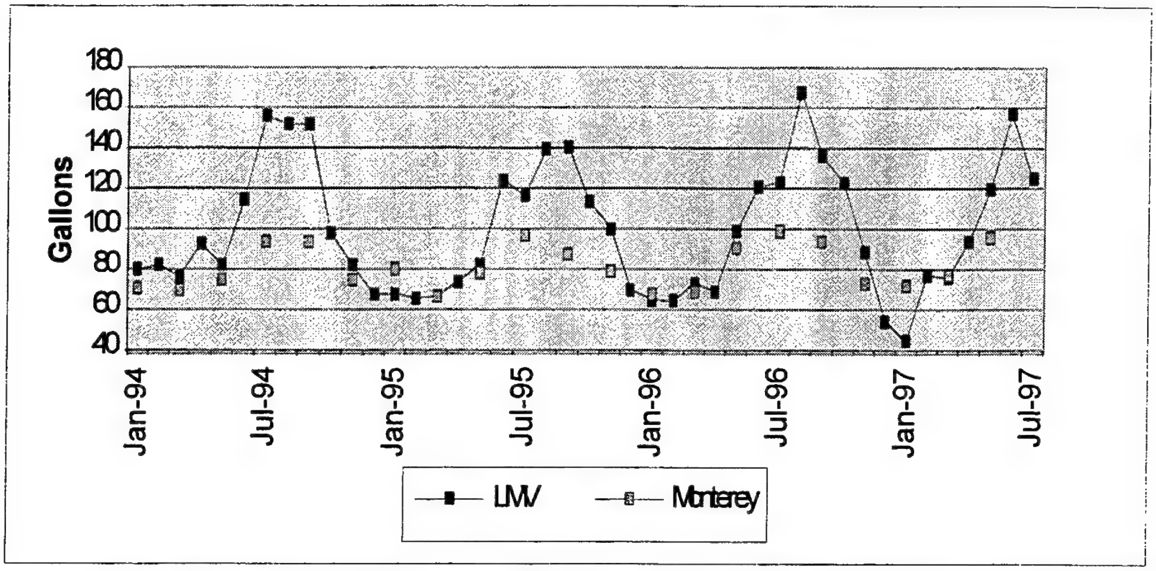


Figure 2.5 LMV Versus Monterey City Water Consumption

Based on the same three year average, LMV residents use approximately 23% more water than Monterey City residents use.

E. CONCLUSIONS BASED ON ARCHIVAL DATA REVIEW

Based on the results of the archival data review, it appears that LMV residents do not practice water conservation method to a large degree. There is not an incentive plan to encourage saving water. Additionally, the residents are not individually monitored on the amount of water they use and therefore are not held accountable for overuse. Over the three years analyzed, LMV residents average

approximately 23% more water usage than PSH residents. In some months LMV consumption rates per resident are as much as 1.69 times as much as their civilian counterparts.

The data from this chapter clearly indicate a need for some type of incentive program to reduce water consumption for GOH residents. Although the data analyzed are for LMV family housing, it can be assumed that the same inefficiencies are being demonstrated in other GOH areas.

III. MODEL SELECTION

A. INTRODUCTION

1. Background

The differences between GOH and PSH water consumption rates were shown in Chapter II. Given the Navy's goal of reducing overall water consumption, and identifying and executing by 2005 all shore facilities water conservation projects with a payback period of less than 10 years, creating an incentive program for GOH residents would be useful towards reaching this goal. Although there are several initiatives that may be created to meet this goal, the primary focus of this thesis is to determine the effects of privatizing water providers for GOH. Residents would then become responsible for paying the water provider for all consumption. A Water Allowance (WA), based on PSH consumption, would be provided to GOH residents to offset the expected costs of this utility. By creating and providing a WA, the resident would then become responsible for water consumption management. This chapter shows how the model and variables are selected and used in forecasting water usage.

2. Model Selection

A critical aspect of creating an incentive program for GOH residents is to accurately forecast future water consumption. Generally, forecasting can be classified as either quantitative or qualitative. Quantitative forecasting methods are based on an analysis of historical data. Qualitative methods generally employ managerial judgment, expertise, and opinions to make forecasts. (Taylor, 1996, p. 583). Qualitative forecasting methods generally utilize the judgment of experts to make forecasts in situations where no historical data are available.

There are generally only three types of forecasting techniques available:

a. It-is-Going-To-Be-Just-Like-Now. This method of forecasting is to assume that things will not change. For most short-term decisions, this is the method used. However, as the period of time the forecast extends the more questionable this technique becomes (Liao, 1997, p. 1).

b. Analysis of the Causative Forces at Work. This is the most rational approach to forecasting. The causative forces operating on the variable to be predicted are analyzed and the forecast is based on the underlying relationship and

on any anticipated changes in these forces and their operation. The most important tool in this method is knowledge of the phenomena under study, professional experience and mature judgment. Mathematical techniques are necessary in this method to determine if certain relationships are important enough to be worthy of consideration. Regression analysis is probably the most frequently and extensively used in this category (Liao, 1997, p. 1).

c. Empirical Regularities in Time. The analysis of the past history of relevant data for the detection of observable and reasonably dependable regularities, and the projection of these regularities into the future is a very widely used forecasting technique. Many of the values of these variables change with time. A function, which gives a variable a value over time, is referred to as a times series (Liao, 1997, p. 1).

Figure 3.1 illustrates an overview of forecasting methods (Anderson, Sweeney, and Williams, 1994, p.687). Since the historical data are available, Figure 3.1 only illustrates the quantitative techniques available.

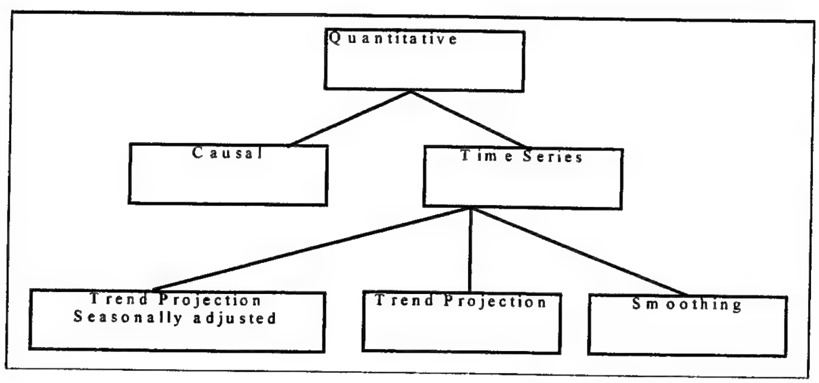


Figure 3.1. Quantitative Forecasting Methods

The first step in determining the appropriate quantitative forecasting model is to determine if time series data are available. Since Chapter II established that data for GOH and PSH water consumption were historical and time series related, then a causal model is not appropriate.

Causal models use regression analysis to show how variables are related. If data on causal factors are available, this method would be used to develop accurate forecasts. Since causal factors are not available, and probably not applicable, time series model will be used for forecasting.

To help explain the pattern or behavior of the data in a time series, it is often helpful to think of time series as consisting of four components. These four

components are: trend, cyclical, seasonal, and random or irregular errors. These components combine to provide specific values for the time series. By analyzing the time series plot, the choice of model selection can be determined. A discussion of the various methods follows (Anderson, Sweeney, and Williams, 1994, p. 687).

a. Forecasting Using Smoothing

If time series data are fairly stable and do not exhibit significant trends, cyclical or seasonal effects, then the objective of the forecasting method is to "smooth out" the irregular component of the time series through an averaging process (Anderson, Sweeney, and Williams, 1994, p. 690). This method can be accomplished by using a moving average, a weighted moving average or exponential smoothing. Since the data in Chapter II indicate a trend and significant seasonal effects, these methods are not discussed.

b. Forecasting Using Trend Projection

If the time series data show some up or down movement that appears linear over time, the data are said to have an upward or downward linear long-term trend. Excluding any significant indication of seasonal or cyclical effects, simple linear trend projection can be used to develop a forecast, based on the historical data. Because not all trends are linear over time, more advanced techniques must be used to forecast curvilinear or nonlinear time series data.

Because of the nature of the data being analyzed in this thesis, this method is not applicable. It is assumed that even in the most stable climates, there will be some seasonal variations in water consumption.

c. Forecasting with Trend and Seasonal Components

If a time series is influenced by more than one component previously mentioned, then the components are superimposed on each other. To determine how the individual components affect a time series, the decomposition method must be used. Data used in this thesis show the presence of strong seasonal and trend components. Therefore, this method is used for forecasting future consumption patterns.

B. TIME SERIES ANALYSIS - THE CLASSICAL DECOMPOSITION METHOD OF FORECASTING

1. Model

A time series may be regarded as affected by and showing the influence of four separate but not necessarily separable groups of forces. Although there are several alternative approaches to decomposing a time series, equation (1) shows

the *multiplicative time series model*, the most common decomposition model where Y is the variable of interest.(Liao, 1997 p.1) :

$$Y = T \times S \times C \times R \qquad (1)$$

From this equation, the trend (T), seasonal variation (S), cyclical variation (C) and random error (R) effects can be isolated to determine the predicted forecast value (Y). It should be noted that cyclical effects are recurrent and do not reflect periodic regularity, therefore, are not susceptible to analysis by the decomposition method unless there is a long history of data (Liao, 1997, p. 3).

Decomposition is best suited for analysis of long-term trends and seasonal fluctuations. The random variation (R) accounts for any random effects in the time series that cannot be explained by the trend and seasonal component process. Random variation, by definition, cannot be analyzed. (Liao, 1997 p. 4). Given the data available for this study, the decomposition method is the most appropriate tool for analysis.

2. Steps to Create a Forecast Using the Decomposition Method

The following discussion provides the steps and procedure used to create forecasted consumption values for GOH and PSH. Microsoft Excel was used to construct the forecast; however, any similar spreadsheet will allow easy computation of data. Additionally, for the purposes of this thesis, the decomposition example used will be data from GOH water consumption. PSH water consumption was decomposed in a similar fashion.

a. Step One

The decomposition method relies on the ratio-to-moving-averages concept for its computation. This method isolates the trend and cyclical factors. The number of terms used for the moving average should equal the length of season. This process will smooth out the data by removing the unusually high and low observations when the values are averaged. In addition, the process will remove periodic variations associated with cyclical periodicity. Therefore, in Equation (2), the moving averages (M) represents: (Liao, 1996, p. 4)

$$M = T \times C \qquad (2)$$

Dividing Equation (1) by Equation (2):

$$Y/M = \frac{T \times S \times C \times R}{T \times C} = S \times R \qquad (3)$$

Equation (3) is the ratio of the actual observed values-to-moving averages, therefore isolating the seasonal and random components of the time

series. The most accurate way of obtaining a moving average is to use the *centered moving average* method.

This method centers the moving average to the middle of the averaged data points. Since the data in this thesis displays a strong 12-month seasonal pattern, it is necessary to compute a *double moving average.* This method alleviates the problem associated with centering moving averages with even numbers of terms. The following formula illustrates the procedure: (Liao, 1997, p.5)

$$M_{6.5} = (Y_1 + Y_2 + \ldots + Y_{11} + Y_{12})/12$$

$$M_{7.5} = (Y_2 + Y_3 + \ldots + Y_{12} + Y_{13})/12$$

$$M_7 = (Y_{6.5} + Y_{7.5})/2, \text{ or}$$

$$M_i = (Y_{i-6} + 2(Y_{i-5} + Y_i + Y_{i+5}) + Y_{i+6})/24 \qquad (4)$$

This procedure calculates the moving average of two twelve-point averages ($M_{6.5}$ and $M_{7.5}$) and sums them together. The average (M_7) is then computed from the two averages ($M_{6.5}$ and $M_{7.5}$) and placed at i=(2+12)/2=7.[11]

In other words, the moving average for a series with a 12-period seasonal cycle, is actually a 13-period weighted moving average and is placed at period seven (Liao, 1997, pp. 6-7). Table 3.1 provides an abbreviated illustration on how the centered moving average for GOH water consumption is computed. Note when using a spreadsheet to compute the moving average, Equation (4) can easily be converted as illustrated in the following formula:

Cell D8 = (period 1 value + period 13 value + 2(period 2 + period 3 +..+ period 12))/24.

[11] i refers to the period in which you are calculating the moving average

Table 3.1. Computation of Centered Moving Averages

Period	Value Gallons	12-Period Averages	Sum of Adjacent Averages	Centered Moving Averages
1	90.16523949	-	-	-
2	97.71927285	-	-	-
3	89.81216044	-	-	-
4	104.4184832	-	-	-
5	177.9332581	-	-	-
6	176.7439392	-	-	-
		$M_{6.5} = 144.16$		
7	195.1783822		291.190332	145.595166
		$M_{7.5} = 147.03$		
8	207.3410263		293.497734	146.748867
		$M_{8.5} = 146.47$		
9	...		...	...
		$M_{9.5} = ...$		
Etc....				

The computations illustrated in Table 3.1 are conducted for the remaining monthly data. Appendices A through D provide the detailed computations for GOH and PSH water data.

b. Step Two

The second phase of the decomposition method is to separate the seasonal variations from the long-term trend and cyclical variations and then isolate the randomness. This is accomplished by dividing the centered moving averages into the raw data of the series, Equation (3). The resulting value isolates the effects of seasonal variations and random errors. To eliminate the randomness from the ratios, some form of averaging (e.g., mean, median, or modal value for the same months) is required. The method used in classical decomposition is an approach called the *modified mean method* (Liao, 1997, pp. 7-9).

c. Step Three

The modified mean method, also called the *medial average method,* computes the mean value for each month after the largest and smallest values have been excluded (Liao, 1997, p. 10). This eliminates the year-to-year fluctuations that are attributed primarily to the random errors. The resulting values represent a reasonable estimate of seasonal influences or *seasonal indexes.* Table 3.2 illustrates the procedure for computing the seasonal index.

Table 3.2 Computation of Seasonal Indices												
Month	87	88	89	90	91	92	93	94	95	96	Med Avg	Adj Avg
Jan		0.88474	0.81788	0.84195	0.89630	0.67335	0.77628	0.75499	0.69882	0.66390	0.777986	0.7826588
Feb		0.65972	0.83148	0.81676	0.85352	0.76734	0.76451	0.76875	0.68991	0.64694	0.761458	0.7660320
Mar		0.83889	0.81534	0.85060	0.80320	0.77018	0.77497	0.71123	0.70719	0.73064	0.778870	0.7835481
Apr		1.02075	0.95638	0.97954	0.89012	1.32158	0.85831	0.86514	0.78421	0.68588	0.909902	0.9153673
May		0.77751	0.89354	0.94011	0.90904	1.06349	0.99196	0.78135	0.86311	0.98647	0.918457	0.9239734
Jun		1.14379	1.04950	1.04641	1.06223	1.48942	0.98548	1.10414	1.28335	1.2139	1.114715	1.1214097
Jul	1.34055	1.36862	1.01716	1.01058	0.98468	1.03808	1.17434	1.52095	1.20376		1.160397	1.1673667
Aug	1.41289	1.37580	1.10118	1.35768	1.36007	1.20715	1.49191	1.50042	1.44898		1.391091	1.3994459
Sep	1.18275	1.34488	1.31697	1.22216	1.30112	1.11269	1.28613	1.51532	1.45178		1.286374	1.2941001
Oct	1.14169	0.94774	1.1433	1.16887	1.03342	1.19615	1.18510	0.99153	1.17089		1.14	1.1468465
Nov	0.83432	0.89865	0.95130	0.90749	0.95971	0.84995	0.99626	0.83909	1.03223		0.911252	0.9167255
Dec	0.85123	0.74663	0.87772	0.87603	0.72967	0.76057	0.77634	0.68398	0.71525		0.777853	0.7825255
											11.92836	12

Indicates Extreme Values

By rearranging the ratios of actual-to-moving averages by month for all years as shown in Table 3.2, a medial average can be computed. This is done by computing the mean value for each month after the largest and smallest values have been excluded. The number of extreme values to be excluded will depend on the number of observations available (Liao, 1997, pp. 9-10).

Since this thesis analyzed data for a 10-year period, the two highest and two lowest values were removed. Note in Table 3.2, that there are only nine years of full data. This is a result of the moving average computations previously discussed. Additonally, the shaded blocks in Table 3.2 are the extreme values; the two largest and smallest values for each month. The remaining five observations for each month were used to compute the mean. For example, by looking at the actual-to-moving average values for January in Table 3.2, we see that the extreme values occur in 1988, 1991, 1992, and 1996. Removing these ratios, we then summed the remaining ratios, 0.81788 + 0.84195 + 0.77628 + 0.75499 + 0.69882 = 3.88992. This is then divided by 5 to obtain the medial value of 0.777986. The remaining months are similarly computed. The sum of the medial averages is 11.92836.

To achieve a more precise seasonal index, an adjustment is made by multiplying each medial average by 1.006 = (12/11.92836). This step adjusts the indices as close to one as possible. If the seasonal pattern remains the same in the future, the adjusted average is used as the seasonal index for the period in question in each cycle, past, current, or future. Using this assumption, seasonal indices can be used to forecast the outcome of a particular month. However, if it is clear that

seasonal patterns are changing then averaged seasonal indices may not be an adequate representation of seasonal variations and then a trend-line must be established. This can be accomplished either by visual curve fitting or by the least square method. In this case, there will be a different seasonal index for each month of the year given a particular month. Forecasting under this condition will be more difficult and requires additional quantitative techniques (Liao, 1997, p. 10).

For the purposes of this thesis, water consumption is assumed to remain constant from year to year. Although it is recognized that there may be periodic increases or decreases in consumption, over the long term, usage will remain consistent based on the users past behavior.

d. Step Four

Once seasonal indices are computed, we can remove the seasonal effects from the time series. Recalling Equation (1), $Y = T \times C \times R \times S$, by dividing the observed value (Y) with the seasonal index (S), the resulting ratio, Y/S is referred to as the *deseasonalized or seasonally adjusted* data (Liao, 1997, p. 11). These values can now be used to determine if a trend exists. The trend line may be linear or nonlinear, depending on the distribution of the deseasonalized data. However, assuming a linear trend exits in the data, then the estimated consumption of water expressed as a function of time can be written as follows, Equation (5):

$$T_t = b_0 + b_1 t \tag{5}$$

In this equation, trend of consumption in period t (T_t) equals the intercept of the trend line (b_0) + the slope of the trend line (b_1) x period t. Simply stated, by conducting regression analysis on the ratio Y/S versus time, the resultant value is the least squared straight line derived from the seasonally adjusted data. Figure 3.2 illustrates the regression output for GOH water consumption.

Regression Statistics	
Multiple R	0.397931
R Square	0.158349
Adjusted R Square	0.151216
Standard Error	20.40188
Observations	120

Analysis Variance

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	9240.712	9240.712	22.20062	6.77E-06
Residual	118	49115.93	416.2367		
Total	119	58356.64			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	120.6466	3.748259	32.18738	1.44E-60	113.2241	128.0692
X Variable 1	-0.25333	0.053766	-4.711753	6.72E-06	-0.3598	-0.14686

Figure 3.2. GOH Regression Output

Note that in the summary output of Figure 3.2, the intercept is 120.6466 and the X variable is –0.25333. These figures represent the intercept of the trend line and slope of the trend line respectively. Therefore, $T_t = 120.6466 – 0.25333t$. Since it does not matter what month is chosen as the base period (t), the base period used in this thesis is December 1986. Therefore, December 1986 equals base period 0, January 1987 equals 1, February 1987 equals 2 and so on. Now using only the trend component, we can now forecast future year water consumption. For example, substituting t =109 into Equation (5) yields a projection for January 1996. Using GOH water consumption data:

$$T_{109} = 120.6466 - 0.25333(109) = 93.0336 \qquad (6)$$

In other words, using Equation (6), the trend projection forecast only, we would expect a GOH resident to consume 93.0336 gallons of water per day in January 1996. However, this projection does not account for the seasonal effects. To gain an accurate forecast, we must adjust the data to reflect seasonal indices.

e. Step Five

To obtain an accurate forecast, we simply include the seasonal effects into our trend forecast. This is accomplished by multiplying the seasonal effect (S) with the trend (T). By multiplying Equation (6) by the seasonal index derived in Table 3.2, the projected water consumption level would be:

$$Y_{\text{Jan 1996}} = 0.66390 \times 93.0336 = 61.765 \text{ gallons}$$

To illustrate the predicting ability of the forecasting model, Table 3.3 shows the actual water consumption per person versus the forecasted water consumption for GOH in 1996.

Table 3.3. GOH Actual vs. Forecasted Daily Water Consumption in 1996

Month	Actual	Forecasted	Error	Percent Error	Absolute Value
Jan-96	64.9108	61.765286	3.14551	5.0927	0.050927
Feb-96	64.19535	60.023324	4.172022	6.9507	0.069507
Mar-96	73.22674	67.604013	5.622724	8.3171	0.083171
Apr-96	68.89687	63.289448	5.607424	8.8600	0.0886
May-96	99.02009	90.775627	8.244464	9.0822	0.090822
Jun-96	120.5022	111.3959	9.106262	8.1747	0.081747
Jul-96	123.0945	110.16088	12.93363	11.7407	0.117407
Aug-96	167.6289	132.23516	35.39377	26.7658	0.267658
Sep-96	135.9354	132.12218	3.813255	2.8862	0.028862
Oct-96	122.7693	106.26309	16.50621	15.5333	0.155333
Nov-96	88.84584	93.417553	-4.57171	-4.8940	0.048938
Dec-96	54.5693	64.549571	-9.98027	-15.4610	0.154614
Monthly	**Average**	**Differences:**	**7.49944**	**MAPE:**	**0.103132**

The data in Table 3.3 suggest that on average, the forecasting model will over predict the amount of water consumed by a resident by 7.49944 gallons of water per person per day. By calculating a Mean, Absolute, Percent Error (MAPE) closeness-of-fit test, we see from Table 3.3, that the MAPE is .103132 or 10.31%. This tells us that the GOH Water Forecasting Model is accurate within 10.31% for 1996. This is not a significant amount, the purpose for forecasting GOH water usage, instead of using a ten-year average, is to allow consistent cost comparisons between forecasted PSH data and GOH data in Chapter IV. This validates the methodology used. Chapter IV provides the analysis of PSH forecasts.

3. Cyclical Effects on Time Series Data

Although not specifically illustrated in part B, section 2 of this chapter, the cyclical effects on time series data can also be analyzed. This is accomplished by dividing the seasonally adjusted data (Y/S) by the trend (T). The result will identify the cyclical component expressed as a percentage of trend.

Cyclical effects are analogous to the seasonal component, but over a longer period of time. Due the length of time involved, it is often difficult to obtain enough relevant data to estimate the cyclical component using the decomposition method. Another difficulty is that the length of cycles usually varies (Anderson,

Sweeney, and Williams, 1994, p. 709). Therefore, using decomposition for analysis of cyclical effects is rarely attempted.

C. CONCLUSIONS

This chapter details the most appropriate model, variables and steps in forecasting future water consumption in GOH. Assuming that historical usage remains constant, there is a need to create an incentive program to encourage savings. Dwindling budget dollars in the Department of the Navy will necessitate the need to consider innovative ideas for reducing overall operating costs. The WA concept will more closely tie the GOH residents' water consumption to the PSH community by allocating a specified dollar amount for water usage. If the GOH resident chooses to consume more, then the difference should be paid "out of pocket." Conversely, being able to retain the difference between the allocated dollar amount and actual payment if consumption is lower would reward the resident.

By conducting an analysis of PSH water consumption, using the method outlined in this chapter, a forecast can be generated for the WA. Using data that are specific to the geographical area of the GOH location, a more precise analysis of the savings can be generated, without penalizing the GOH resident. Chapter IV provides an in depth analysis of savings that could be generated if a WA concept were to be instituted in GOH housing area using PSH consumption data.

IV. ANALYSIS BASED ON PUBLIC SECTOR CONSUMPTION

A. ANALYSIS OF PSH FORECASTED VALUES

1. Introduction

Chapter II demonstrated that La Mesa Village residents consume more water than the average PSH resident. Utilizing the model outlined in Chapter III, this chapter analyzes the forecasted values generated from PSH data and develops a baseline consumption rate per month to be applied to LMV residents under the WA concept. All forecasts in this chapter are based on per person per day consumption.

Additionally, this chapter assumes that if the WA concept was implemented in LMV, the rate schedule would be changed to the standard residential schedules as outlined in Chapter I. All cost-benefit analysis under the WA concept uses the standard CAL-AM Residential and Program for Alternative Rates(PAR) service rates.

2. Analysis of Monterey's Forecasted Water Consumption

a. Analysis of the Historical Data

As discussed in Chapter II, there is a definite seasonal effect in the historical data. The highest consumption occurring in the months of July and August and the lowest consumption occurring in the months of March and April. Appendix 3 provides the detailed decomposition of Monterey's water consumption for the past three years using the procedure outlined in Chapter III. Figure 4.1

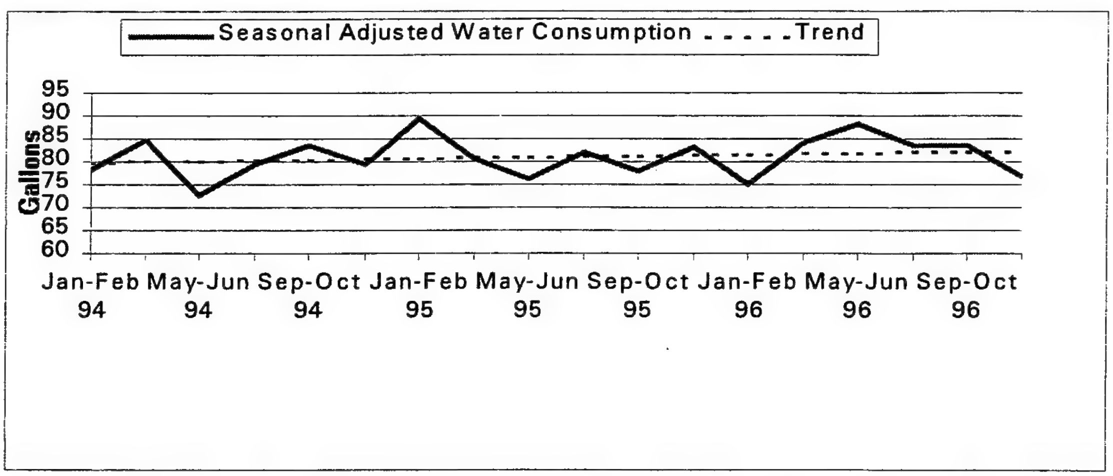


Figure 4.1. Water Consumption, Monterey City (Y/S vs. T)

shows the seasonally adjusted consumption data (Y/S) plotted against the trend (T). The trend is the least square equation from conducting a regression of the deseasonalized data versus time. By including the seasonal effect into our trend, as illustrated in Figure 4.1, we can see that there are no large deviations. There are small deviations that do not normally occur form year to year and therefore can be treated as random errors.

If we take a closer look a the smooth trend line (T), it is obvious that as time passes the consumption of water is increasing. Explaining this increase is at best difficult, however it is likely that now that the drought of 1989 through 1992 is over, residents are less aware of a water shortages. By using the smooth trend line and adding the seasonal effect back in, we can obtain a forecast of expected future consumption.

b. Analysis of Monterey's Water Forecast

Including the seasonal effect into the trend, as illustrated in Figure 4.2. we obtain a fairly accurate forecast of future behavior.

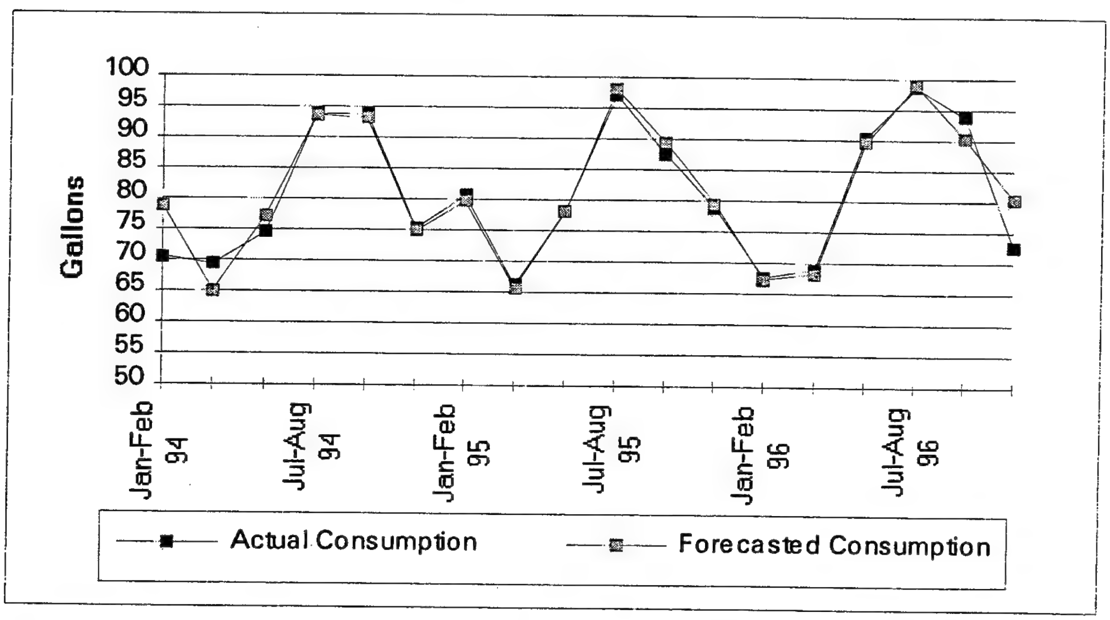


Figure 4.2 Actual vs. Forecasted Water Consumption, Monterey City

We can see the forecasted values are consistent with historical consumption. Although forecasted consumption is not exact, it is very close, this is a good indication that the historical data is predictive of future consumption patterns. To take a closer look at the data we can compare historical data with forecasted data for 1996. This will give us a precise indication of how well the

forecasting model predicts usage. Table 4.1 shows the actual and forecasted values for 1996.

Month	Actual	Forecasted	Error	Percent Error	Absolute Value
Jan-Feb 96	67.585	67.280067	0.304933	0.4532	0.004532
Mar-Apr 96	68.94	68.195558	0.744442	1.0916	0.010916
May-Jun 96	90.495	89.655312	0.839688	0.9366	0.009366
Jul-Aug 96	98.615	99.02859	-0.41359	-0.418	0.004176
Sep-Oct 96	93.865	90.346239	3.518761	3.8948	0.038948
Nov-Dec 96	72.675	80.340955	-7.66595	-9.542	0.095418
Monthly	**Average**	**Differences:**	**-0.44529**	**MAPE:**	**0.027226**

Table 4.1 Actual vs. Forecasted Water Consumption, Monterey City (in gallons per person per day)

The data in Table 4.1 suggest that on average, the forecasting model will under predict the amount of water consumed by a resident by .44529 gallons of water per person per day. Notice that November- December data have the largest difference, this difference is still less than ten percent. By calculating a Mean, Absolute, Percent Error (MAPE) closeness-of-fit test, we see from Table 4.1, that the MAPE is .027226 or 2.72%. This tells us that the PSH Water Forecasting Model is accurate within 2.72% for 1996. This is a very insignificant amount.

3. Summary of PSH Forecast

As noted and shown in the previous sections, all data used to forecast consumption demonstrate similar patterns, including seasonal patterns and trends. Although there were some random errors present, the cause cannot be specifically identified. Using the decomposition method smoothes out these random errors by using the sum of the square regression line as the foundation for the forecast. When seasonal effects were added back into the model, it was demonstrated that the forecasted values in all cases are predictive of future consumption pattern.

The model was used to determine forecast consumption for future years to establish a consumption baseline for PSH. This baseline will be used for the WA concept. By comparing the baseline to the historical consumption rates of LMV resident, the potential savings can be analyzed.

B. ESTABLISHMENT OF BASELINE USAGE RATE

1. Determination of Water Allowance Baseline

By using the forecasting model developed in the previous sections, we can set a baseline water consumption rate for LMV residents. Table 4.2 compares the forecasted values for 1997 between Monterey and LMV.

Month	Monterey (Daily in Gallons)	LMV (Daily in Gallons)	Difference (Daily in Gallons)
Jan-97	74.260648	59.747048	-14.51360047
Feb-97	74.260648	58.056651	-16.2039968
Mar-97	67.623722	65.382893	-2.240829533
Apr-97	67.623722	61.204374	-6.41934837
May-97	84.678859	87.776786	3.097926492
Jun-97	84.678859	107.7057	23.02683593
Jul-97	97.801724	106.50148	8.699760605
Aug-97	97.801724	127.83029	30.0285659
Sep-97	93.172881	127.70882	34.53594304
Oct-97	93.172881	102.70361	9.530732331
Nov-97	78.75501	90.279602	11.5245925
Dec-97	78.75501	62.375226	-16.37978356
Average	82.715474	88.106041	5.390566505

Table 4.2 Forecasted Water Consumption Monterey City vs LMV(in gallons per person per day)

Notice the differences in water consumption varies according to the season. The largest difference occur in the summer months as expected, based on historical data and the forecasting model.

C. COST-BENEFIT ANALYSIS

1. Cost of Implementing the WA Concept at LMV

Before a water monitoring program can be implement at LMV, first the water meters must be installed for each unit. This thesis assumes all water monitoring will be conduct by the local water company, CAL-AM, which will incur some of the cost for the meter installation.

Based on engineering estimates, the cost to install a single, 3/4 inch 26 gallon per minute water meter would total $400.00 per installation (Brego, 1997, Interview). This cost includes the material at $200.00, labor at $200.00 and includes overhead and profit. CAL-AM would provide the meters at no charge, although they would make up for some cost of the meter and personnel to monitor the meter though the standard rate which includes a meter charge. Total cost of

metering LMV, would be a one-time charge of $237,200.00. This figure is based on installing meters in the 593 units at LMV. Only 593 meters need to be installed, because NPS Housing is taking 284 units out of service permanently by January 1998. This number of residents will remain approximately the same as historical data has shown in Chapter II, however, the occupancy rate will increase to approximately 99%.

2. Savings Generated from Implementing a WA Program

Using the standard CAL-AM for Residential and Program for Alternative Rates(PAR) service rates and the forecasted baseline consumption rates form the previous sections, the expected total water savings per resident per year would be $6.97. Total savings based on the historical average number of residents of 2672, would be $18,635.00 per year under the WA concept. Appendix 8 provide the detailed savings breakdown per day and per month using PSH and LMV forecasts for 1997 and CAL-AM rate schedules from the previous sections.

Since annual water savings generated from switching to a WA concept is $18,635.00 per year, the payback period for installation and metering boxes is essentially 12.7 years. This does meets the Navy's Goal to identify and implement by 2005, all life cycle cost-effective water conservation measures with a payback period of less than 10 years.

V. SUMMARY AND CONCLUSIONS

A. SUMMARY

Chapter I outlined the Department of the Navy's water strategy, with the goal to identify and implement by 2005, all life cycle cost-effective water conservation measures with a payback period of less than 10 years. As was shown in Chapter II, the annual average water consumption for LMV residents is 1.23 to 1.69 times higher than the PSH residents' consumption. Because the GOH resident does not pay for utilities, there are no real incentives for the GOH resident to reduce overall consumption.

Given a finite amount of resources, PSH residents will generally employ some type of water reduction program. The water consumption data for the city of Monterey presumably reflects this rational behavior. Therefore, it is logical to use the PSH water consumption patterns as a benchmark to evaluate any incentive programs targeted at GOH residents. One recommendation, and the focus of this thesis, was to institute a Water Allowance (WA) based on the local PSH consumption rates. GOH residents would then use the allowance to pay the utility provider directly. Any water consumption above the baseline established for the WA would be paid "out of pocket" by the GOH resident.

B. CONCLUSIONS

This thesis explored the savings that could be generated by instituting a WA at the Naval Postgraduate School's La Mesa Village housing complex. Using past water consumption rates, and then generating a forecasting model to predict future consumption, a comparison was made between LMV and PSH residents. Chapter IV demonstrated that, by instituting a WA based on PSH consumption, the Navy could save approximately $18,635.00 annually. There is a one-time charge of installing meter boxes and plumbing connections in existing homes. This one time cost of approximately $237,200.00 could not be recouped within the 10-year timeframe goal. The WA concept would reduce water consumption and overall costs to the Navy, it could be implemented and have a payback period of approximately 12.7 years, This timeframe would allow the initial metering cost to be recouped. Additionally, under the WA concept, residents would become more observant about water usage. Table 5.1 provides an illustration of the average

reductions that could be achieved by implementation of a WA based on 1997 forecasted values per month.

Current	WA
88.12 Gallons	82.72 Gallons
Savings	6.12%

Table 5.1. Average Water Savings Per Person Per Day.

Of course there may be GOH residents that exceed the baseline rates established, but it is also assumed that others will be below it. Therefore, due to the fact that water is relatively inexpensive as compared to other utilities, it would take longer for the LMV residents to meet the goals set by the Navy.

Consumer water costs will continue to increase in the long-term, because of the limited amount of source water available to Central California and population growth. Sewer costs will also continue to increase because of more stringent Clean Water Act standards. Monterey Peninsula residents will face tighter water-conservation rules shortly including limiting outdoor watering. This is a result of the California-American Water Company's failure to meet state orders to trim pumping from the Carmel River by 20 percent. To meet current water requirements from residents, CAL-AM is pumping more water from the Carmel River than allowed.(Parsons, 1997, p.1) This trend will continue in the foreseeable future. This will mean that more fines will be levied and the rates for water will go up. If this is the case then the payback from the WA concept could be potentially more significant than this thesis predicts.

Although this study focused on the Naval Postgraduate School's family housing area, it is assumed that similar inefficiencies in water consumption are being demonstrated in other GOH areas. Therefore, the benefits derived from implementing a WA concept are potentially significant when applied to all GOH residents.

C. RECOMMENDATIONS

The following actions are recommended:

- Implement a Water Allowance concept based on the local Public Sector Housing consumption rates. Even though as demonstrated in this thesis, the initial metering costs may not be recovered within ten years, doing so will reduce the overall water costs currently being

paid. Additionally, the timeframe of recouping the initial cost is very close to the ten-year goal.

- Implement the forecasting methods developed in Chapter III to assess the differences in GOH water consumption and PSH consumption.
- Implement a monitoring program for water consumption. Although the Navy is responsible for some costs, as outlined in Chapter IV, generally, the Utility Company subsidizes the monitoring of the meters and other costs.
- Investigate methods to lower the initial metering costs. Determine is it is cheaper to contract out or to install the meters by PWC.
- Require all residents of GOH to attend water conservation seminars. As stated in Chapter I, the current energy awareness programs do not target individual residents. Combined training with representatives from Naval Facilities Engineering Command, Southwest Division, Public Works, Housing, and Residents, can foster new and innovative solutions to reducing overall water consumption.

D. FOLLOW-ON RESEARCH

The study of implementing a Water Allowance as an incentive for GOH residents to reduce water consumption has generated a number of related issues that were not addressed in this thesis. These issues may serve as possible topics for further study.

Although this study proposes a WA concept to reduce consumption of water, the thesis did not explore all the possible incentive programs that could be implemented. One possible research topic might be to determine the effectiveness of water consumption monitoring programs that are implemented and conducted by the various Navy Commands. Since the utility provider will not pay for these costs, this study should include the cost of installing meters and the personnel to monitor the program. It should also include the most cost effective monitoring systems, such as telemetry type meters versus personnel monitored meters. Additionally, a procedure to enforce compliance would also have to be analyzed. After determining the specific procedures for implementing this system it could be compared to the proposed program, as outlined in this thesis, to determine the most cost effective alternative.

As stated in Chapter I of this thesis, due to the scope and time limitation, the lot size and square footage of individual homes between PSH and GOH were assumed to be equal. As a means of reducing water consumption and ultimately costs, a study determining the exact vegetation and efficiency of such vegetation of GOH compared to PSH would be extremely beneficial.

A detailed analysis of the water requirements for different family sizes would also be beneficial. Although this thesis used the aggregate PSH home and compared it to the aggregate GOH home, it did not specifically address the individual water needs based on family size. If the water requirements based on family size are significantly different from the findings in this thesis, then the baseline rates established in Chapter IV may have to be adjusted.

Because of time limitations this thesis did not research the laws and regulations that might preclude the implementation of the WA concept. A study that researches any restrictions with regards to the WA concept would be beneficial. The research should detail any modifications to existing laws and regulations that would be required to allow the implementation of the WA concept.

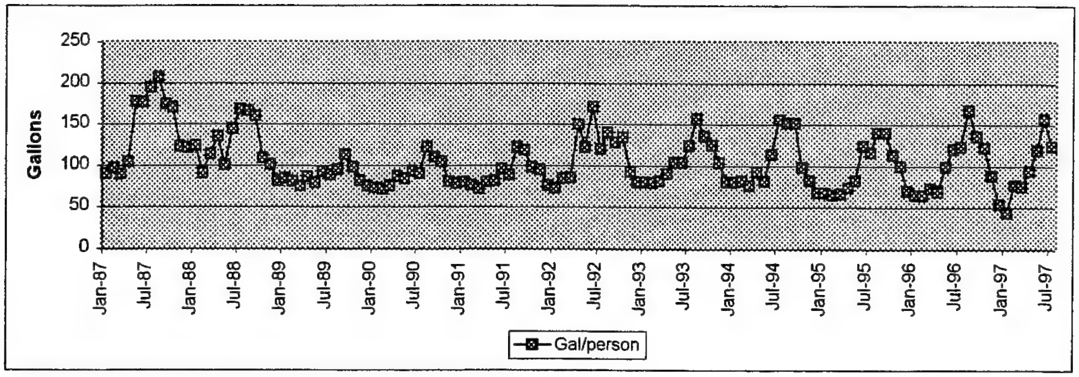
APPENDIX A. LA MESA WATER CONSUMPTION PER PERSON PER DAY IN GALLONS

La Mesa Water Consumption Per House in Gallons

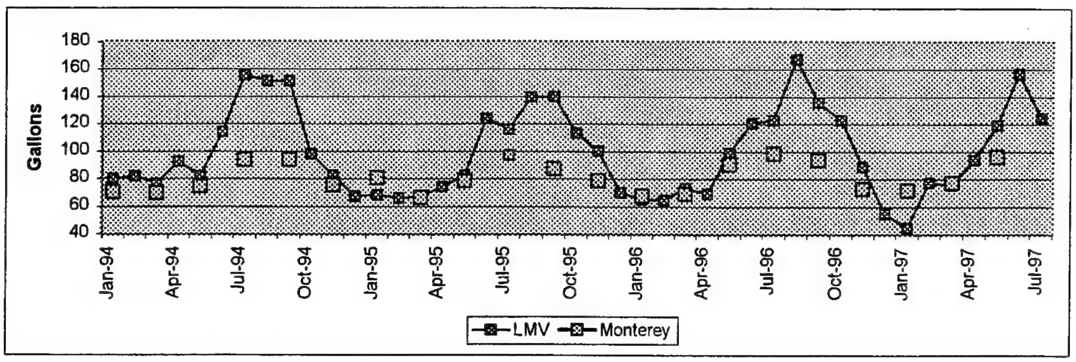
Month	Period	100 cubic ft	gal/pers/day	MA	Y/MA	S	Y/S	T	Y*T*S	Error	Percent Error	Absolute Value	Regression Output
Jan-87	1	9704	90.16523949			0.78265887	115.203754	120.393311	94.2268922	-4.0616527	-0.043105027	0.043105027	120.646641
Feb-87	2	10517	97.71927285			0.76603205	127.565515	120.139981	92.031076	5.68819682	0.061807349	0.061807349	-0.253329961
Mar-87	3	9666	89.81216044			0.78354813	114.622391	119.886651	93.9369615	-4.1248011	-0.04391031	0.04391031	
Apr-87	4	11238	104.4184832			0.91536735	114.072763	119.633321	109.508437	-5.0899534	-0.046480012	0.046480012	
May-87	5	19150	177.9332581			0.92397342	192.574	119.379991	110.303939	67.6293187	0.613117892	0.613117892	
Jun-87	6	19022	176.7439392			1.12140979	157.6087	119.126661	133.589804	43.1541351	0.323034647	0.323034647	
Jul-87	7	21006	195.1783822	145.595166	1.34055537	1.16736676	167.195425	118.873331	138.768776	56.4096065	0.406500714	0.406500714	
Aug-87	8	22315	207.3410263	146.748867	1.41289695	1.39944592	148.15937	118.620001	166.002277	41.3387491	0.249025193	0.249025193	
Sep-87	9	18772	174.4210507	147.469737	1.18275827	1.29410012	134.781729	118.366671	153.178323	21.2427274	0.138679723	0.138679723	
Oct-87	10	18401	170.9738842	149.754685	1.14169306	1.14684654	149.081745	118.113341	135.457877	35.5160068	0.262192258	0.262192258	
Nov-87	11	13272	123.317504	147.805394	0.83432343	0.91672553	134.519549	117.860011	108.045281	15.272223	0.141350209	0.141350209	
Dec-87	12	13122	121.9237709	143.231627	0.85123498	0.78252551	155.808045	117.606681	92.030229	29.8935419	0.324823074	0.324823074	
Jan-88	13	13405	124.5532806	140.779431	0.88474062	0.78265887	159.141212	117.353352	91.8476409	32.7056397	0.356085789	0.356085789	
Feb-88	14	9796	91.02006245	137.966413	0.65972624	0.76603205	118.820175	117.100022	89.7023696	1.31769285	0.01468961	0.01468961	
Mar-88	15	12249	113.8122443	135.669463	0.8388936	0.78354813	145.252397	116.846692	91.5550069	22.2572374	0.243102351	0.243102351	
Apr-88	16	14557	135.2571508	132.506851	1.02075591	0.91536735	147.762699	116.593362	106.725757	28.5313938	0.267333722	0.267333722	
May-88	17	10796	100.3116164	129.015937	0.77751338	0.92397342	108.565478	116.340032	107.495098	-7.1834811	-0.066826128	0.066826128	
Jun-88	18	15562	144.5951625	126.417012	1.14379513	1.12140979	128.940521	116.086702	130.180764	14.4143989	0.110726028	0.110726028	
Jul-88	19	18132	168.4744561	123.097217	1.36862929	1.16736676	144.320073	115.833372	135.220028	33.2544281	0.245928274	0.245928274	
Aug-88	20	17923	166.5325214	121.043783	1.375804	1.39944592	118.998897	115.580042	161.748018	4.78450316	0.02957998	0.02957998	
Sep-88	21	17231	160.102766	119.045712	1.34488478	1.29410012	123.71745	115.326712	149.244311	10.8584548	0.072756239	0.072756239	
Oct-88	22	11773	109.3894646	115.420457	0.94774763	1.14684654	95.3828262	115.073382	131.97151	-22.582046	-0.171113035	0.171113035	
Nov-88	23	10883	101.1199816	112.523428	0.89865713	0.91672553	110.305624	114.820052	105.258472	-4.1384909	-0.039317413	0.039317413	
Dec-88	24	8798	81.74709162	109.487413	0.74663461	0.78252551	104.46572	114.566722	89.6513831	-7.9042915	-0.088166977	0.088166977	
Jan-89	25	9154	85.05488482	103.994169	0.81788129	0.78265887	108.674275	114.313392	89.4683897	-4.4135048	-0.049330326	0.049330326	
Feb-89	26	8743	81.23605615	97.7003026	0.83148213	0.76603205	106.047855	114.060062	87.3736632	-6.137607	-0.070245504	0.070245504	
Mar-89	27	8141	75.64254067	92.7738433	0.8153434	0.78354813	96.5384737	113.806732	89.1730523	-13.530512	-0.151733189	0.151733189	
Apr-89	28	9301	86.42074325	90.3615236	0.95638874	0.91536735	94.4109956	113.553402	103.943077	-17.522334	-0.168576248	0.168576248	
May-89	29	8569	79.61932576	89.105228	0.8935427	0.92397342	86.1705798	113.300072	104.686256	-25.06693	-0.239448147	0.239448147	
Jun-89	30	9947	92.4230871	88.0637997	1.04950147	1.12140979	82.4168721	113.046742	126.771723	-34.348636	-0.27094872	0.27094872	
Jul-89	31	9558	88.80867261	87.3100224	1.0171647	1.16736676	76.0760676	112.793412	131.67128	-42.862608	-0.325527386	0.325527386	
Aug-89	32	10240	95.1455124	86.4025473	1.10118874	1.39944592	67.9879879	112.540082	157.493759	-62.348247	-0.395877571	0.395877571	
Sep-89	33	12189	113.254751	85.996429	1.3169704	1.29410012	87.5162204	112.286752	145.310299	-32.055548	-0.220600662	0.220600662	
Oct-89	34	10584	98.34180696	86.0157864	1.14329952	1.14684654	85.7497522	112.033422	128.485143	-30.143336	-0.234605617	0.234605617	
Nov-89	35	8827	82.01654668	86.2147805	0.95130494	0.91672553	89.4668517	111.780092	102.471664	-20.455117	-0.199617304	0.199617304	
Dec-89	36	8164	75.85624641	86.4238404	0.87772362	0.78252551	96.9377292	111.526762	87.2725372	-11.416291	-0.13081195	0.13081195	
Jan-90	37	7841	72.85507449	86.5310805	0.84195267	0.78265887	93.0866278	111.273432	87.0891384	-14.234064	-0.16344247	0.16344247	
Feb-90	38	7712	71.65646403	87.7320138	0.81676529	0.76603205	93.5423838	111.020103	85.0449567	-13.388493	-0.157428415	0.157428415	
Mar-90	39	8123	75.4752927	88.7316301	0.85060189	0.78354813	96.3250242	110.766773	86.7910977	-11.315805	-0.130379789	0.130379789	
Apr-90	40	9369	87.05256892	88.8706163	0.97954276	0.91536735	95.1012383	110.513443	101.160398	-14.107829	-0.139459996	0.139459996	
May-90	41	9015	83.76335882	89.0990337	0.94011523	0.92397342	90.6555931	110.260113	101.877414	-18.114055	-0.177802463	0.177802463	
Jun-90	42	10041	93.29649317	89.1582673	1.04641438	1.12140979	83.1957186	110.006783	123.362683	-30.06619	-0.243721918	0.243721918	
Jul-90	43	9741	90.50902699	89.5612885	1.01058201	1.16736676	77.5326401	109.753453	128.122533	-37.613506	-0.293574478	0.293574478	
Aug-90	44	13159	122.2675584	90.0556766	1.35768852	1.39944592	87.3685481	109.500123	153.2395	-30.971942	-0.20211461	0.20211461	
Sep-90	45	11852	110.1234974	90.1052315	1.22216541	1.29410012	85.0965825	109.246793	141.376287	-31.25279	-0.221061046	0.221061046	
Oct-90	46	11280	104.8087285	89.6662056	1.16887659	1.14684654	91.3886248	108.993463	124.998776	-20.190048	-0.161521963	0.161521963	
Nov-90	47	8721	81.03164196	89.2918334	0.9074922	0.91672553	88.3924792	108.740133	99.6848555	-18.653214	-0.187121839	0.187121839	
Dec-90	48	8423	78.26275889	89.3371297	0.87603843	0.78252551	100.013044	108.486803	84.8936913	-6.6309324	-0.078108659	0.078108659	
Jan-91	49	8623	80.12106967	89.390169	0.8963074	0.78265887	102.37036	108.233473	84.7098871	-4.5888174	-0.054170978	0.054170978	
Feb-91	50	8207	76.25578323	89.3425498	0.85352146	0.76603205	99.5464657	107.980143	82.7162503	-6.4604671	-0.078103965	0.078103965	
Mar-91	51	7756	72.0652924	89.7219549	0.80320689	0.78354813	91.9730256	107.726813	84.4091431	-12.343851	-0.146238313	0.146238313	
Apr-91	52	8602	79.92594704	89.7916416	0.8901268	0.91536735	87.3157063	107.473483	98.3777178	-18.451771	-0.187560468	0.187560468	
May-91	53	8815	81.90504803	90.1005858	0.90904013	0.92397342	88.6443764	107.220153	99.0685721	-17.163524	-0.173248929	0.173248929	
Jun-91	54	10358	96.24191577	90.6034911	1.06223187	1.12140979	85.822254	106.966823	119.953643	-23.711727	-0.197674087	0.197674087	
Jul-91	55	9561	88.83654728	90.2186659	0.98468035	1.16736676	76.0999458	106.713493	124.573785	-35.737238	-0.286876068	0.286876068	
Aug-91	56	13216	122.7971769	90.286804	1.3600789	1.39944592	87.7469968	106.460163	148.985241	-26.188064	-0.175776232	0.175776232	
Sep-91	57	12775	118.6996017	91.2283481	1.30112628	1.29410012	91.7236619	106.206833	137.442275	-18.742674	-0.136367603	0.136367603	
Oct-91	58	10537	97.90510393	94.7382326	1.0334276	1.14684654	85.3689663	105.953503	121.512409	-23.607305	-0.194278966	0.194278966	
Nov-91	59	10262	95.34992659	99.3522635	0.9597157	0.91672553	104.011423	105.700173	96.898047	-1.5481204	-0.015976797	0.015976797	
Dec-91	60	8181	76.01420283	104.174967	0.7296782	0.78252551	97.1395838	105.446843	82.5148454	-6.5006426	-0.078781491	0.078781491	
Jan-92	61	7871	73.13382111	108.61091	0.67335612	0.78265887	93.4427812	105.193513	82.3306358	-9.1968147	-0.111705863	0.111705863	
Feb-92	62	9135	84.87834529	110.612853	0.76734614	0.76603205	110.802603	104.940183	80.3875439	4.49080141	0.055864394	0.055864394	
Mar-92	63	9260	86.03978954	111.713515	0.77018246	0.78354813	109.807919	104.686853	82.0271885	4.01260108	0.04891794	0.04891794	
Apr-92	64	16164	150.188678	113.643061	1.32158248	0.91536735	164.074759	104.433524	95.5950381	54.5936398	0.571092819	0.571092819	
May-92	65	13171	122.379057	115.072411	1.06349607	0.92397342	132.448676	104.180194	96.2597303	26.1193268	0.271342198	0.271342198	
Jun-92	66	18459	171.5127943	115.1541	1.48941979	1.12140979	152.943907	103.926864	116.544602	54.9681921	0.471649404	0.471649404	
Jul-92	67	12918	120.0282939	115.624484	1.03808717	1.16736676	102.819695	103.673534	121.025037	-0.9967433	-0.008235844	0.008235844	
Aug-92	68	15030	139.6520558	115.687202	1.20715216	1.39944592	99.7909627	103.420204	144.730982	-5.0789265	-0.035092186	0.035092186	
Sep-92	69	13804	128.2606107	115.269857	1.11269862	1.29410012	99.1118144	103.166874	133.508263	-5.2476527	-0.039305827	0.039305827	
Oct-92	70	14492	134.6531998	112.571822	1.19615369	1.14684654	117.411698	102.913544	118.026042	16.6271578	0.140877026	0.140877026	
Nov-92	71	9999	92.9062479	109.307776	0.84995095	0.91672553	101.345763	102.660214	94.1112385	-1.2049906	-0.012803897	0.012803897	
Dec-92	72	8655	80.4183994	105.733625	0.76057545	0.78252551	102.767767	102.406884	80.1359995	0.2823999	0.003524008	0.003524008	
Jan-93	73	8612	80.01886258	103.079338	0.77628421	0.78265887	102.23977	102.153554	79.9513846	0.06747802	0.000843988	0.000843988	
Feb-93	74	8556	79.49853556	103.985265	0.76451732	0.76603205	103.779647	101.900224	78.0588375	1.43969811	0.018443755	0.018443755	
Mar-93	75	8761	81.40330412	105.039469	0.77497825	0.78354813	103.890624	101.646894	79.6452339	1.75807027	0.022073766	0.022073766	

Apr-93	76	9694	90.07232395	104.941133	0.85831286	0.91536735	98.4001926	101.393564	92.8123584	-2.7400345	-0.029522302	0.029522302		
May-93	77	11210	104.1583197	105.002303	0.99196224	0.92397342	112.728696	101.140234	93.4508884	10.7074313	0.114578165	0.114578165		
Jun-93	78	11188	103.9539055	105.485076	0.98548448	1.12140979	92.6993028	100.886904	113.135562	-9.1816562	-0.081156235	0.081156235		
Jul-93	79	13333	123.8842888	105.492432	1.1743429	1.16736676	106.122851	100.633574	117.476289	6.40799928	0.054547171	0.054547171		
Aug-93	80	16955	157.5382972	105.595026	1.4919102	1.39944592	112.571908	100.380244	140.476723	17.0615738	0.12145481	0.12145481		
Sep-93	81	14602	135.6752707	105.490883	1.28613266	1.29410012	104.841402	100.126914	129.574251	6.10101933	0.047085121	0.047085121		
Oct-93	82	13440	124.878485	105.37319	1.18510681	1.14684654	108.888574	99.8735842	114.539675	10.3388101	0.090264008	0.090264008		
Nov-93	83	11209	104.1490282	104.539273	0.996267	0.91672553	113.609827	99.6202543	91.32443	12.8245982	0.140428998	0.140428998		
Dec-93	84	8692	80.7621869	104.029012	0.77634292	0.78252551	103.207097	99.3669243	77.7571536	3.00503329	0.03864639	0.03864639		
Jan-94	85	8594	79.85161461	105.764597	0.7549938	0.78265887	102.026078	99.1135944	77.5721333	2.27948132	0.029385312	0.029385312		
Feb-94	86	8839	82.12804533	106.832739	0.76875353	0.76603205	107.212283	98.8602644	75.730131	6.3979143	0.084483075	0.084483075		
Mar-94	87	8209	76.27436634	107.241954	0.71123626	0.78354813	97.3448385	98.6069344	77.2632792	-0.9889129	-0.012799261	0.012799261		
Apr-94	88	9942	92.37662933	106.776215	0.86514238	0.91536735	100.917548	98.3536045	90.0296787	2.34695062	0.026068633	0.026068633		
May-94	89	8808	81.84000715	104.741365	0.78135326	0.92397342	88.5739838	98.1002745	90.6420466	-8.8020395	-0.097107687	0.097107687		
Jun-94	90	12272	114.02595	103.270589	1.10414738	1.12140979	101.680894	97.8469446	109.726521	4.2994286	0.03918313	0.03918313		
Jul-94	91	16732	155.4662806	102.216385	1.52095264	1.16736676	133.176895	97.5936146	113.927542	41.5387389	0.364606646	0.364606646		
Aug-94	92	16315	151.5917026	101.032873	1.50041959	1.39944592	108.322658	97.3402846	136.222464	15.3692382	0.11282455	0.11282455		
Sep-94	93	16299	151.4430378	99.9407285	1.51532854	1.29410012	117.025751	97.0869547	125.640239	25.8027984	0.205370497	0.205370497		
Oct-94	94	10540	97.93297859	98.7688313	0.99153728	1.14684654	85.3932718	96.8336247	111.053308	-13.120329	-0.118144425	0.118144425		
Nov-94	95	8853	82.25812708	98.0320885	0.8390939	0.91672553	89.730377	96.5802948	88.5376215	-6.2794944	-0.070924589	0.070924589		
Dec-94	96	7249	67.35447455	98.4738245	0.68398353	0.78252551	86.0731992	96.3269648	75.3783077	-8.0238332	-0.10644751	0.10644751		
Jan-95	97	7314	67.95842556	97.2473393	0.69882041	0.78265887	86.8301997	96.0736348	75.192882	-7.2344565	-0.096211985	0.096211985		
Feb-95	98	7062	65.61695397	95.1091205	0.68991232	0.76603205	85.6582358	95.8203049	73.4014246	-7.7844706	-0.1060534	0.1060534		
Mar-95	99	7165	66.57398402	94.1377659	0.70719741	0.78354813	84.9647665	95.5669749	74.8813246	-8.3073406	-0.110940086	0.110940086		
Apr-95	100	7959	73.95147785	94.299981	0.78421519	0.91536735	80.7888522	95.313645	87.246999	-13.295521	-0.152389438	0.152389438		
May-95	101	8888	82.58333147	95.6805511	0.86311513	0.92397342	89.3784705	95.060315	87.8332048	-5.2498733	-0.059770941	0.059770941		
Jun-95	102	13333	123.8842888	96.5315025	1.28335606	1.12140979	110.471917	94.806985	106.317481	17.5668077	0.165229721	0.165229721		
Jul-95	103	12503	116.172299	96.5074994	1.20376447	1.16736676	99.5165383	94.5536551	110.378794	5.79350492	0.052487482	0.052487482		
Aug-95	104	15021	139.5684318	96.3212811	1.44898853	1.39944592	99.7312076	94.3003251	131.968205	7.60022636	0.057591344	0.057591344		
Sep-95	105	15084	140.1537997	96.5392455	1.45178056	1.29410012	108.30213	94.0469951	121.706227	18.4475723	0.151574596	0.151574596		
Oct-95	106	12174	113.1153777	96.605835	1.17089592	1.14684654	98.6316594	93.7936652	107.566941	5.54843697	0.051581247	0.051581247		
Nov-95	107	10785	100.2094093	97.0800914	1.03223439	0.91672553	109.312337	93.5403352	85.750813	14.4585963	0.168611769	0.168611769		
Dec-95	108	7515	69.8260279	97.6240344	0.71525448	0.78252551	89.2316309	93.2870053	72.9994618	-3.1734339	-0.043472018	0.043472018		
Jan-96	109	6986	64.91079587	97.7715378	0.66390276	0.78265887	82.9362558	93.0336753	72.8136307	-7.9028349	-0.108535103	0.108535103		
Feb-96	110	6909	64.19534621	99.2291504	0.6469404	0.76603205	83.8024286	92.7803453	71.0727182	-6.877372	-0.096765287	0.096765287		
Mar-96	111	7881	73.22673665	100.222572	0.73064116	0.78354813	93.455314	92.5270154	72.49937	0.72736662	0.01003273	0.01003273		
Apr-96	112	7415	68.89687251	100.449054	0.68588871	0.91536735	75.2669103	92.2736854	84.4643193	-15.567447	-0.184307965	0.184307965		
May-96	113	10657	99.0200904	100.377819	0.98647382	0.92397342	107.167682	92.0203555	85.024363	13.9957274	0.164608436	0.164608436		
Jun-96	114	12969	120.5021631	99.2686395	1.21389961	1.12140979	107.455958	91.7670255	102.908441	17.5937224	0.170964814	0.170964814		
Jul-96	115	13248	123.0945067			1.16736676	105.446301	91.5136955	106.830046	16.2644603	0.152246122	0.152246122		
Aug-96	116	18041	167.6289247			1.39944592	119.782352	91.2603656	127.713946	39.9149782	0.312534217	0.312534217		
Sep-96	117	14630	135.9354342			1.29410012	105.04244	91.0070356	117.772215	18.1632188	0.154223292	0.154223292		
Oct-96	118	13213	122.7693023			1.14684654	107.049459	90.7537057	104.080574	18.6887286	0.1795602	0.1795602		
Nov-96	119	9562	88.84583883			0.91672553	96.9165103	90.5003757	82.9640045	5.88183433	0.07089622	0.07089622		
Dec-96	120	5873	54.56929632			0.78252551	69.7348461	90.2470457	70.6206159	-16.05132	-0.227289431	0.227289431	MAPE	
Jan-97	121	4779	44.40433631								Sum=	17.5424454	0.146187045	
Feb-97	122	8302	77.13848086											
Mar-97	123	8144	75.67041533											
Apr-97	124	10111	93.94690195											
May-97	125	12841	119.3128442											
Jun-97	126	16888	156.915763											
Jul-97	127	13395	124.4603651											
Aug-97	128		0											
Sep-97	129		0											
Oct-97	130		0											
Nov-97	131		0											
Dec-97	132		0											

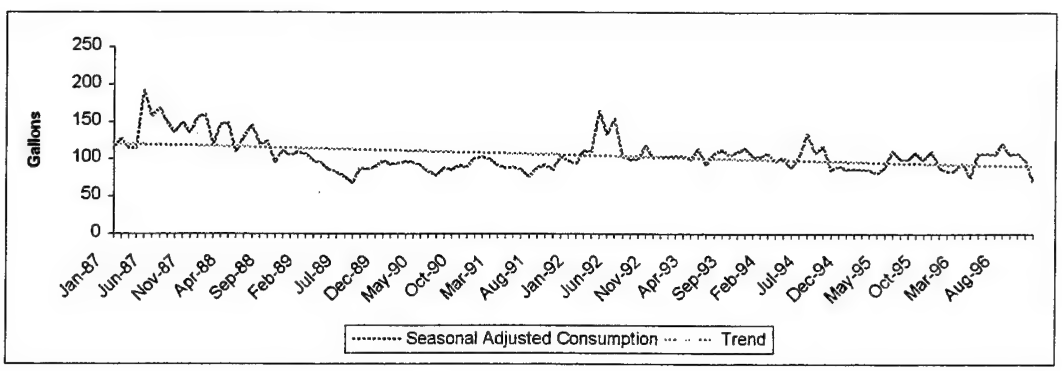
Seasonality Calculations												
Month/Year	87	88	89	90	91	92	93	94	95	96	Med Avg	Adj Avg
Jan		0.88474062	0.817881288	0.84195267	0.6963074	0.67335613	0.77628421	0.7549938	0.69882041	0.66390276	0.777986475	0.782658865
Feb		0.65972624	0.831482135	0.81676529	0.85352146	0.76734614	0.76451732	0.76875353	0.68991232	0.6469404	0.761458921	0.76603205
Mar		0.8388936	0.815343399	0.85060159	0.80320689	0.77018246	0.77497825	0.71123626	0.70719741	0.73064116	0.778870433	0.783548132
Apr		1.02072591	0.956388735	0.97954276	0.8901268	1.32158246	0.85831286	0.86514238	0.78421519	0.68588871	0.909902709	0.915367354
May		0.77751338	0.893542697	0.94011523	0.90904013	1.06349607	0.99196224	0.78135326	0.86311513	0.98647382	0.918457402	0.923973425
Jun		1.14379513	1.049501468	1.04641436	1.06223187	1.46941979	0.98548448	1.10414738	1.28335606	1.21389961	1.114715092	1.121409789
Jul	1.34055537	1.36862929	1.017164699	1.01058201	0.98458035	1.03808717	1.1743429	1.52095264	1.20376447		1.160397706	1.167366761
Aug	1.41289695	1.375804	1.101188743	1.35768852	1.3600789	1.20716216	1.4919102	1.50041959	1.44898853		1.39109138	1.399445922
Sep	1.18275827	1.34488478	1.316970395	1.22216641	1.30112628	1.11268862	1.28613266	1.51532854	1.45178056		1.286374478	1.294100117
Oct	1.14169306	0.94774263	1.143289517	1.16887659	1.0334276	1.19619369	1.18510681	0.99153728	1.17089592		1.139999993	1.146846544
Nov	0.83432343	0.89865713	0.951304941	0.9074922	0.9597157	0.84995095	0.996267	0.8390939	1.03223439		0.911252772	0.916725526
Dec	0.85123499	0.74663461	0.877723624	0.87603843	0.7296782	0.76057545	0.77634292	0.68398353	0.71525448		0.777853921	0.782525515
											11.92836128	12



Gallons
250
200
150
100
50
0
Jan-87
Jul-87
Jan-88
Jul-88
Jan-89
Jul-89
Jan-90
Jul-90
Jan-91
Jul-91
Jan-92
Jul-92
Jan-93
Jul-93
Jan-94
Jul-94
Jan-95
Jul-95
Jan-96
Jul-96
Jan-97
Jul-97
Gal/person



Gallons
180
160
140
120
100
80
60
40
Jan-94
Apr-94
Jul-94
Oct-94
Jan-95
Apr-95
Jul-95
Oct-95
Jan-96
Apr-96
Jul-96
Oct-96
Jan-97
Apr-97
Jul-97
LMV
Monterey

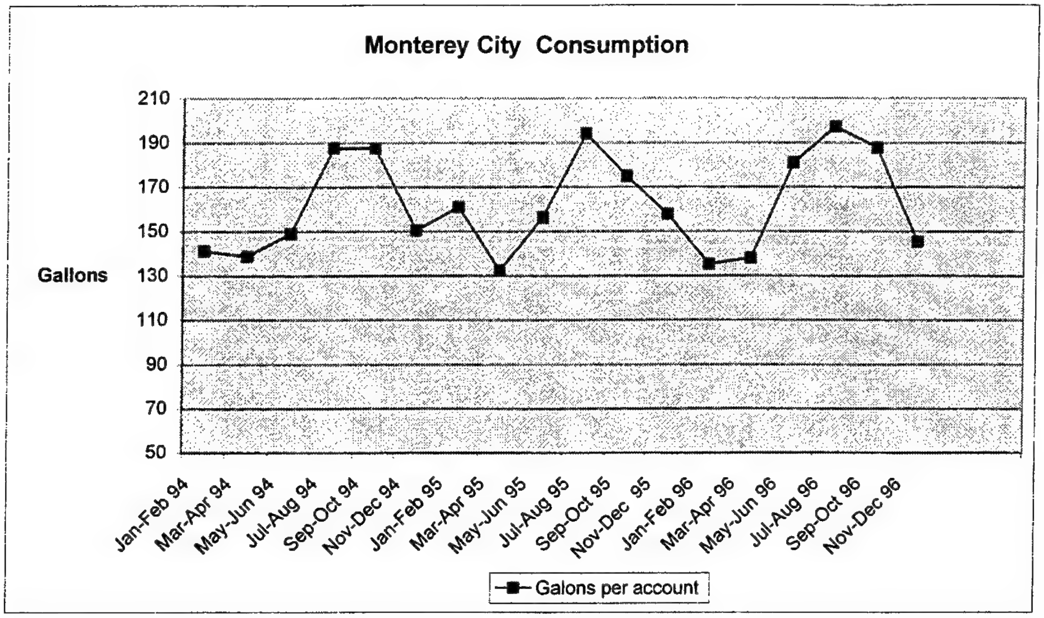


Gallons
250
200
150
100
50
0
Jan-87
Jun-87
Nov-87
Apr-88
Sep-88
Feb-89
Jul-89
Dec-89
May-90
Oct-90
Mar-91
Aug-91
Jan-92
Jun-92
Nov-92
Apr-93
Sep-93
Feb-94
Jul-94
Dec-94
May-95
Oct-95
Mar-96
Aug-96
Seasonal Adjusted Consumption
Trend

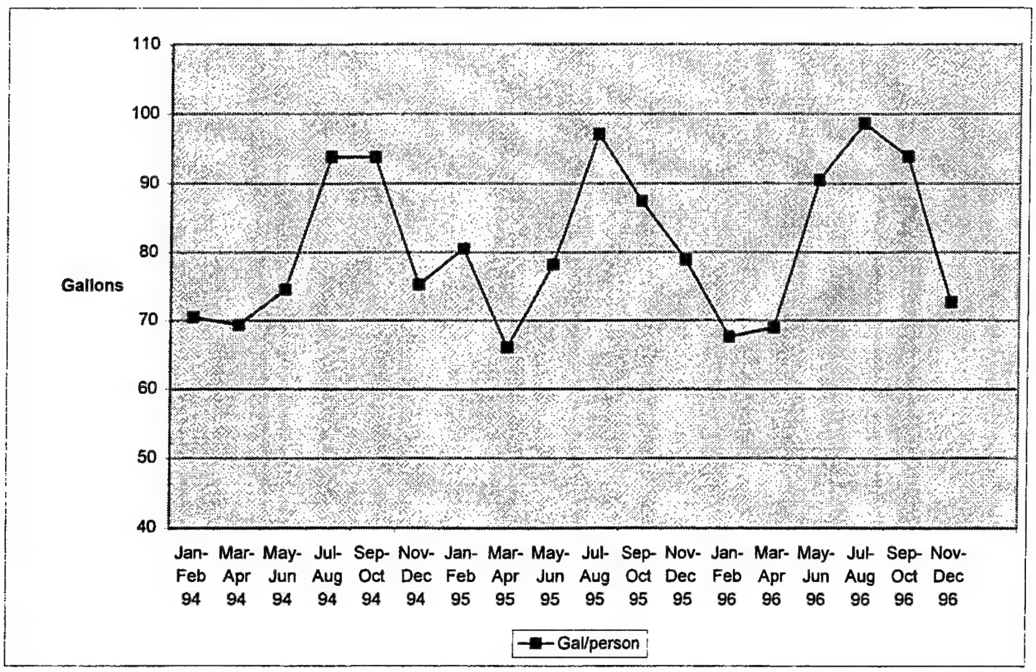
APPENDIX B. MONTEREY WATER CONSUMPTION PER PERSON PER DAY IN GALLONS

Monterey City Water Consumption Per Account In Gallons													
Month	Period	Gals/day/acc	gal/pers/day	MA	Y/MA	S	Y/S	T	Y=T*S	Error	Percent Error	Absolute Value	Regression Output
Jan-Feb 94	1	141.08	70.54			0.90180852	78.2205957	79.7991734	71.9635748	-1.4235748	-0.019781881	0.019781881	79.65766316
Mar-Apr 94	2	138.69	69.345			0.81980203	84.5874949	79.9406837	65.5355347	3.80946525	0.058128239	0.058128239	0.14151026
May-Jun 94	3	149.01	74.505			1.02480329	72.7017575	80.0821939	82.0684955	-7.5634955	-0.092160767	0.092160767	
Jul-Aug 94	4	187.59	93.795	80.3670833	1.16708229	1.18159566	79.3799461	80.2237042	94.7919809	-0.9969809	-0.010517566	0.010517566	
Sep-Oct 94	5	187.54	93.77	80.93	1.15865563	1.12375086	83.4437624	80.3652145	90.310479	3.45952096	0.038306972	0.038306972	
Nov-Dec 94	6	150.49	75.245	80.965	0.92935219	0.94823964	79.3523042	80.5067247	76.3396673	-1.0946673	-0.01433943	0.01433943	
Jan-Feb 95	7	161.09	80.545	81.5425	0.98776712	0.90180852	89.3149685	80.648235	72.7292658	7.8157342	0.1074634	0.1074634	
Mar-Apr 95	8	132.19	66.095	81.28875	0.81308914	0.81980203	80.6231231	80.7897452	66.2315971	-0.1365971	-0.002062416	0.002062416	
May-Jun 95	9	156.35	78.175	81.06625	0.96433473	1.02480329	76.2829326	80.9312555	82.9386165	-4.7636165	-0.057435447	0.057435447	
Jul-Aug 95	10	194.11	97.055	80.2891667	1.20881813	1.18159566	82.1389271	81.0727658	95.7952283	1.25977166	0.013150672	0.013150672	
Sep-Oct 95	11	174.93	87.465	79.44625	1.10093302	1.12375086	77.8330882	81.214276	91.2646127	-3.7996127	-0.041632924	0.041632924	
Nov-Dec 95	12	157.76	78.88	80.71	0.97732623	0.94823964	83.1857234	81.3557863	77.1447811	1.73521886	0.022493017	0.022493017	
Jan-Feb 96	13	135.17	67.585	81.8666667	0.82554967	0.90180852	74.9438469	81.4972965	73.4949567	-5.9099567	-0.080413092	0.080413092	
Mar-Apr 96	14	137.88	68.94	82.53	0.83533261	0.81980203	84.0934732	81.6388068	66.9276595	2.01234047	0.030067396	0.030067396	
May-Jun 96	15	180.99	90.495	82.54625	1.0962945	1.02480329	88.304752	81.7803171	83.8087376	6.68626239	0.079780016	0.079780016	
Jul-Aug 96	16	197.23	98.615			1.18159566	83.4591757	81.9218273	96.7984758	1.81652421	0.018766041	0.018766041	
Sep-Oct 96	17	187.73	93.865			1.12375086	83.5283008	82.0633376	92.2187464	1.64625364	0.017851616	0.017851616	
Nov-Dec 96	18	145.35	72.675			0.94823964	76.6420188	82.2048478	77.949895	-5.274895	-0.067670328	0.067670328	
											Sum=	0.772021221	MAPE
													0.00643351

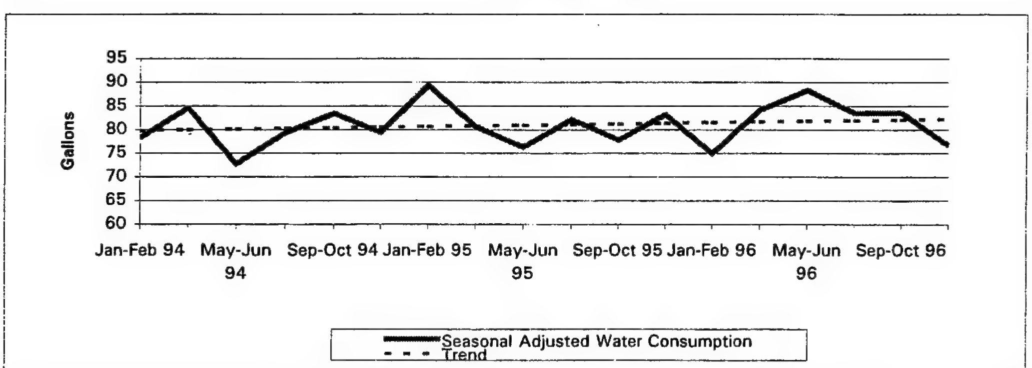
Seasonality Calculations					
Month/Year	94	95	96	Med Avg	Adj Avg
Jan-Feb		0.98776712	0.82554967	0.90665839	0.90180852
Mar-Apr		0.81308914	0.83533261	0.82421087	0.81980203
May-Jun		0.96433473	1.0962945	1.03031461	1.02480329
Jul-Aug	1.16708229	1.20881813		1.18795021	1.18159566
Sep-Oct	1.15865563	1.10093302		1.12979432	1.12375086
Nov-Dec	0.92935219	0.97732623		0.95333921	0.94823964
				6.03226783	6



Monterey City Consumption
Gallons
210
190
170
150
130
110
90
70
50
Jan-Feb 94
Mar-Apr 94
May-Jun 94
Jul-Aug 94
Sep-Oct 94
Nov-Dec 94
Jan-Feb 95
Mar-Apr 95
May-Jun 95
Jul-Aug 95
Sep-Oct 95
Nov-Dec 95
Jan-Feb 96
Mar-Apr 96
May-Jun 96
Jul-Aug 96
Sep-Oct 96
Nov-Dec 96
Galons per account



Gallons
110
100
90
80
70
60
50
40
Jan-Feb 94
Mar-Apr 94
May-Jun 94
Jul-Aug 94
Sep-Oct 94
Nov-Dec 94
Jan-Feb 95
Mar-Apr 95
May-Jun 95
Jul-Aug 95
Sep-Oct 95
Nov-Dec 95
Jan-Feb 96
Mar-Apr 96
May-Jun 96
Jul-Aug 96
Sep-Oct 96
Nov-Dec 96
Gal/person



Gallons
95
90
85
80
75
70
65
60
Jan-Feb 94
May-Jun 94
Sep-Oct 94
Jan-Feb 95
May-Jun 95
Sep-Oct 95
Jan-Feb 96
May-Jun 96
Sep-Oct 96
Seasonal Adjusted Water Consumption
Trend

APPENDIX C. MONTEREY CITY CONSUMPTION FORECAST PER PERSON PER DAY IN GALLONS

Monterey City Water Consumption Per Account In Gallons

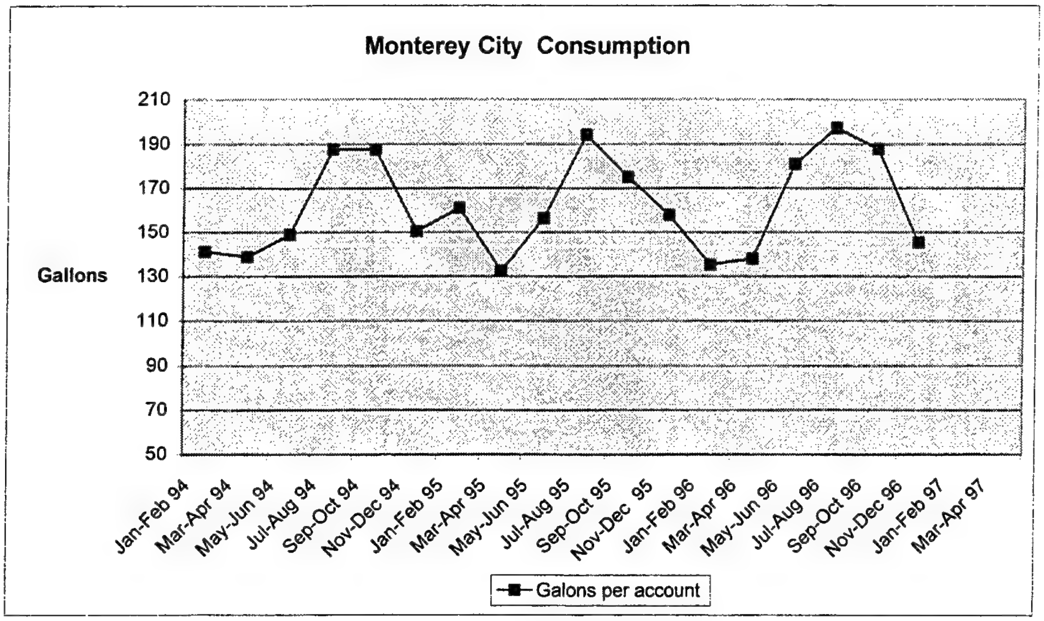
Month	Period	Gals/day/acc	gal/pers/day	MA	Y/MA	S	Y/S	T	Y=T*S	Error	Percent Error	Absolute Value
Jan-Feb 94	1	141.08	70.54			0.90180852	78.2205957	79.7991734	71.9635748	-1.4235748	-0.019781881	0.019781881
Mar-Apr 94	2	138.69	69.345			0.81980203	84.5874949	79.9406837	65.5355347	3.80946525	0.058128239	0.058128239
May-Jun 94	3	149.01	74.505			1.02480329	72.7017575	80.0821939	82.0684955	-7.5634955	-0.092160767	0.092160767
Jul-Aug 94	4	187.59	93.795	80.3670833	1.16708229	1.18159566	79.3799461	80.2237042	94.7919809	-0.9969809	-0.010517566	0.010517566
Sep-Oct 94	5	187.54	93.77	80.93	1.15865563	1.12375086	83.4437624	80.3652145	90.310479	3.45952096	0.038306972	0.038306972
Nov-Dec 94	6	150.49	75.245	80.965	0.92935219	0.94823964	79.3523042	80.5067247	76.3396673	-1.0946673	-0.01433943	0.01433943
Jan-Feb 95	7	161.09	80.545	81.5425	0.98776712	0.90180852	89.3149685	80.648235	72.7292658	7.8157342	0.1074634	0.1074634
Mar-Apr 95	8	132.19	66.095	81.28875	0.81308914	0.81980203	80.6231231	80.7897452	66.2315971	-0.1365971	-0.002062416	0.002062416
May-Jun 95	9	156.35	78.175	81.06625	0.96433473	1.02480329	76.2829326	80.9312555	82.9386165	-4.7636165	-0.057435447	0.057435447
Jul-Aug 95	10	194.11	97.055	80.2891667	1.20881813	1.18159566	82.1389271	81.0727658	95.7952283	1.25977166	0.013150672	0.013150672
Sep-Oct 95	11	174.93	87.465	79.44625	1.10093302	1.12375086	77.8330882	81.214276	91.2646127	-3.7996127	-0.041632924	0.041632924
Nov-Dec 95	12	157.76	78.88	80.71	0.97732623	0.94823964	83.1857234	81.3557863	77.1447811	1.73521886	0.022493017	0.022493017
Jan-Feb 96	13	135.17	67.585	81.8666667	0.82554967	0.90180852	74.9438469	81.4972965	73.4949567	-5.9099567	-0.080413092	0.080413092
Mar-Apr 96	14	137.88	68.94	82.53	0.83533261	0.81980203	84.0934732	81.6388068	66.9276595	2.01234047	0.030067396	0.030067396
May-Jun 96	15	180.99	90.495	82.54625	1.0962945	1.02480329	88.304752	81.7803171	83.8087376	6.68626239	0.079780016	0.079780016
Jul-Aug 96	16	197.23	98.615			1.18159566	83.4591757	81.9218273	96.7984758	1.81652421	0.018766041	0.018766041
Sep-Oct 96	17	187.73	93.865			1.12375086	83.5283008	82.0633376	92.2187464	1.64625364	0.017851616	0.017851616
Nov-Dec 96	18	145.35	72.675			0.94823964	76.6420188	82.2048478	77.949895	-5.274895	-0.067670328	0.067670328
Jan-Feb 97	19					0.90180852		82.3463581	74.2606477		Sum=	0.772021221
Mar-Apr 97	20					0.81980203		82.4878684	67.6237219			
May-Jun 97	21					1.02480329		82.6293786	84.6788587			
Jul-Aug 97	22					1.18159566		82.7708889	97.8017232			
Sep-Oct 97	23					1.12375086		82.9123991	93.17288			
Nov-Dec 97	24					0.94823964		83.0539094	78.7550088			

Regression Output
79.65766316
0.14151026

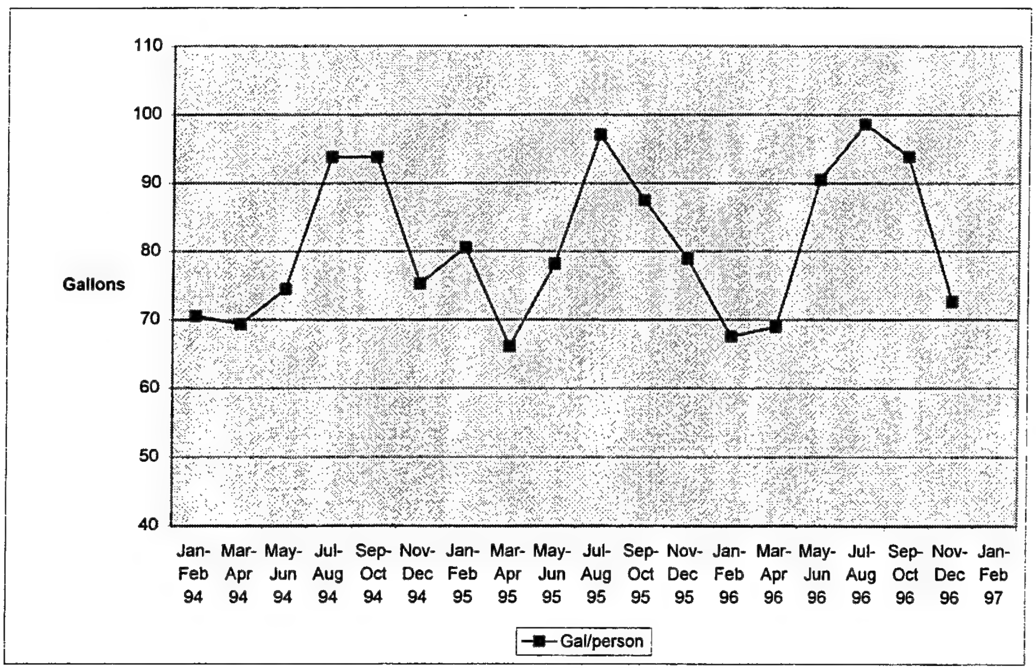
MAPE
0.00643351

Seasonality Calculations

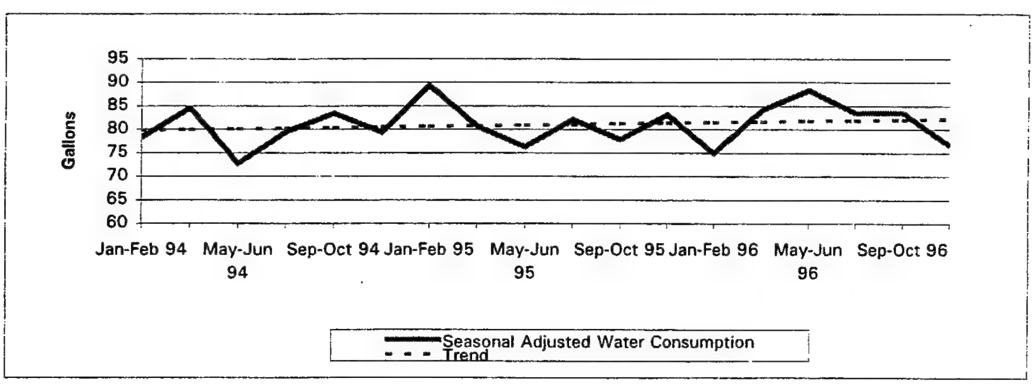
Month/Year	94	95	96	Med Avg	Adj Avg
Jan-Feb		0.98776712	0.82554967	0.90665839	0.90180852
Mar-Apr		0.81308914	0.83533261	0.82421087	0.81980203
May-Jun		0.96433473	1.0962945	1.03031461	1.02480329
Jul-Aug	1.16708229	1.20881813		1.18795021	1.18159566
Sep-Oct	1.15865563	1.10093302		1.12979432	1.12375086
Nov-Dec	0.92935219	0.97732623		0.95333921	0.94823964
				6.03226763	6



Monterey City Consumption
210
190
170
150
Gallons
130
110
90
70
50
Jan-Feb 94
Mar-Apr 94
May-Jun 94
Jul-Aug 94
Sep-Oct 94
Nov-Dec 94
Jan-Feb 95
Mar-Apr 95
May-Jun 95
Jul-Aug 95
Sep-Oct 95
Nov-Dec 95
Jan-Feb 96
Mar-Apr 96
May-Jun 96
Jul-Aug 96
Sep-Oct 96
Nov-Dec 96
Jan-Feb 97
Mar-Apr 97
Galons per account



110
100
90
80
Gallons
70
60
50
40
Jan-Feb 94
Mar-Apr 94
May-Jun 94
Jul-Aug 94
Sep-Oct 94
Nov-Dec 94
Jan-Feb 95
Mar-Apr 95
May-Jun 95
Jul-Aug 95
Sep-Oct 95
Nov-Dec 95
Jan-Feb 96
Mar-Apr 96
May-Jun 96
Jul-Aug 96
Sep-Oct 96
Nov-Dec 96
Jan-Feb 97
Gal/person



95
90
85
80
75
70
65
60
Gallons
Jan-Feb 94
May-Jun 94
Sep-Oct 94
Jan-Feb 95
May-Jun 95
Sep-Oct 95
Jan-Feb 96
May-Jun 96
Sep-Oct 96
Seasonal Adjusted Water Consumption
Trend

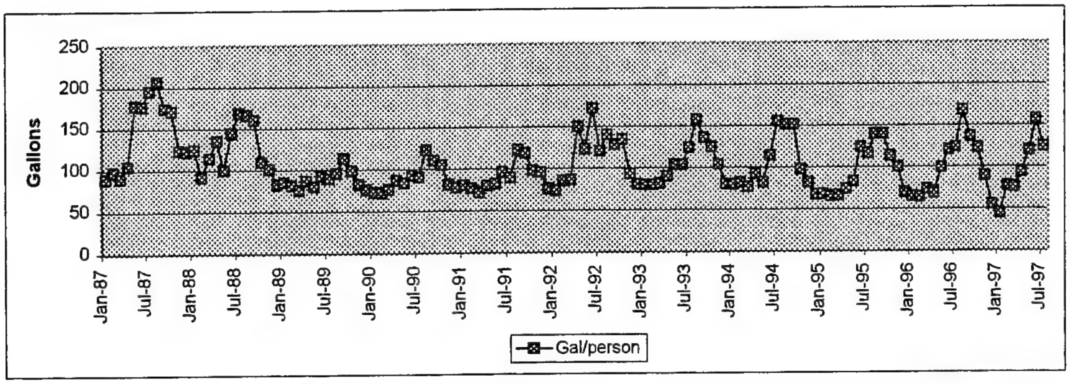
APPENDIX D. LA MESA WATER CONSUMPTION FORECAST PER PERSON PER DAY IN GALLONS

La Mesa Water Consumption Per House in Gallons													
Month	Period	100 cubic ft	gal/pers/day	MA	Y/MA	S	Y/S	T	Y*T*S	Error	Percent Error	Absolute Value	Regression Output
Jan-87	1	9704	90.16523949			0.78265887	115.203754	120.393311	94.2268922	-4.0616527	-0.043105027	0.043105027	120.646641
Feb-87	2	10517	97.71927285			0.76603205	127.565515	120.139981	92.031076	5.68819682	0.061807349	0.061807349	-0.253329961
Mar-87	3	9666	89.81216044			0.78354813	114.622391	119.886651	93.9369615	-4.1248011	-0.04391031	0.04391031	
Apr-87	4	11238	104.4184832			0.91536735	114.072763	119.633321	109.508437	-5.0899534	-0.046480012	0.046480012	
May-87	5	19150	177.9332581			0.92397342	192.574	119.379991	110.303939	67.6293187	0.613117892	0.613117892	
Jun-87	6	19022	176.7439392			1.12140979	157.6087	119.126661	133.589804	43.1541351	0.323034647	0.323034647	
Jul-87	7	21006	195.1783822	145.595166	1.34055537	1.16736676	167.195425	118.873331	138.768776	56.4096065	0.406500714	0.406500714	
Aug-87	8	22315	207.3410263	146.748867	1.41289695	1.39944592	148.15937	118.620001	166.002277	41.3387491	0.249025193	0.249025193	
Sep-87	9	18772	174.4210507	147.469737	1.18275827	1.29410012	134.781729	118.366671	153.178323	21.2427274	0.138679723	0.138679723	
Oct-87	10	18401	170.9738842	149.754685	1.14169306	1.14684654	149.081745	118.113341	135.457877	35.5160068	0.262192258	0.262192258	
Nov-87	11	13272	123.317504	147.805394	0.83432343	0.91672553	134.519549	117.860011	108.045281	15.272223	0.141350209	0.141350209	
Dec-87	12	13122	121.9237709	143.231627	0.85123498	0.78252551	155.808045	117.606681	92.030229	29.8935419	0.324823074	0.324823074	
Jan-88	13	13405	124.5532806	140.779431	0.88474062	0.78265887	159.141212	117.353352	91.8476409	32.7056397	0.356085789	0.356085789	
Feb-88	14	9796	91.02006245	137.966413	0.65972624	0.76603205	118.820175	117.100022	89.7023696	1.31769285	0.01468961	0.01468961	
Mar-88	15	12249	113.8122443	135.669463	0.8388936	0.78354813	145.252397	116.846692	91.5550069	22.2572374	0.243102351	0.243102351	
Apr-88	16	14557	135.2571508	132.506851	1.02075591	0.91536735	147.762699	116.593362	106.725757	28.5313938	0.267333722	0.267333722	
May-88	17	10796	100.3116164	129.015937	0.77751338	0.92397342	108.565478	116.340032	107.495098	-7.1834811	-0.066826128	0.066826128	
Jun-88	18	15562	144.5951625	126.417012	1.14379513	1.12140979	128.940521	116.086702	130.180764	14.4143989	0.110726028	0.110726028	
Jul-88	19	18132	168.4744561	123.097217	1.36862929	1.16736676	144.320073	115.833372	135.220028	33.2544281	0.245928274	0.245928274	
Aug-88	20	17923	166.5325214	121.043783	1.375804	1.39944592	118.998897	115.580042	161.748018	4.78450316	0.02957998	0.02957998	
Sep-88	21	17231	160.102766	119.045712	1.34488478	1.29410012	123.71745	115.326712	149.244311	10.8584548	0.072756239	0.072756239	
Oct-88	22	11773	109.3894646	115.420457	0.94774763	1.14684654	95.3828262	115.073382	131.97151	-22.582046	-0.171113035	0.171113035	
Nov-88	23	10883	101.1199816	112.523428	0.89865713	0.91672553	110.305624	114.820052	105.258472	-4.1384909	-0.039317413	0.039317413	
Dec-88	24	8798	81.74709162	109.487413	0.74663461	0.78252551	104.46572	114.566722	89.6513831	-7.9042915	-0.088166977	0.088166977	
Jan-89	25	9154	85.05488482	103.994169	0.81788129	0.78265887	108.674275	114.313392	89.4683897	-4.4135048	-0.049330326	0.049330326	
Feb-89	26	8743	81.23605615	97.7003026	0.83148213	0.76603205	106.047855	114.060062	87.3736632	-6.137607	-0.070245504	0.070245504	
Mar-89	27	8141	75.64254067	92.7738433	0.8153434	0.78354813	96.5384737	113.806732	89.1730523	-13.530512	-0.151733189	0.151733189	
Apr-89	28	9301	86.42074325	90.3615236	0.95638874	0.91536735	94.4109956	113.553402	103.943077	-17.522334	-0.168576248	0.168576248	
May-89	29	8569	79.61932576	89.105228	0.8935427	0.92397342	86.1705798	113.300072	104.686256	-25.06693	-0.239448147	0.239448147	
Jun-89	30	9947	92.4230871	88.0637997	1.04950147	1.12140979	82.4168721	113.046742	126.771723	-34.348636	-0.27094872	0.27094872	
Jul-89	31	9558	88.80867261	87.3100224	1.0171647	1.16736676	76.0760676	112.793412	131.67128	-42.862608	-0.325527386	0.325527386	
Aug-89	32	10240	95.1455124	86.4025473	1.10118874	1.39944592	67.9879879	112.540082	157.493759	-62.348247	-0.395877571	0.395877571	
Sep-89	33	12189	113.254751	85.996429	1.3169704	1.29410012	87.5162204	112.286752	145.310299	-32.055548	-0.220600662	0.220600662	
Oct-89	34	10584	98.34180696	86.0157864	1.14329952	1.14684654	85.7497522	112.033422	128.485143	-30.143336	-0.234605617	0.234605617	
Nov-89	35	8827	82.01654668	86.2147805	0.95130494	0.91672553	89.4668517	111.780092	102.471664	-20.455117	-0.199617304	0.199617304	
Dec-89	36	8164	75.85624641	86.4238404	0.87772362	0.78252551	96.9377292	111.526762	87.2725372	-11.416291	-0.13081195	0.13081195	
Jan-90	37	7841	72.85507449	86.5310805	0.84195267	0.78265887	93.0866278	111.273432	87.0891384	-14.234064	-0.16344247	0.16344247	
Feb-90	38	7712	71.65646403	87.7320138	0.81676529	0.76603205	93.5423838	111.020103	85.0449567	-13.388493	-0.157428415	0.157428415	
Mar-90	39	8123	75.4752927	88.7316301	0.85060189	0.78354813	96.3250242	110.766773	86.7910977	-11.315805	-0.130379789	0.130379789	
Apr-90	40	9369	87.05256892	88.8706163	0.97954276	0.91536735	95.1012383	110.513443	101.160398	-14.107829	-0.139459996	0.139459996	
May-90	41	9015	83.76335882	89.0990337	0.94011523	0.92397342	90.6555931	110.260113	101.877414	-18.114055	-0.177802463	0.177802463	
Jun-90	42	10041	93.29649317	89.1582673	1.04641438	1.12140979	83.1957186	110.006783	123.362683	-30.06619	-0.243721918	0.243721918	
Jul-90	43	9741	90.50902699	89.5612885	1.01058201	1.16736676	77.5326401	109.753453	128.122533	-37.613506	-0.293574478	0.293574478	
Aug-90	44	13159	122.2675584	90.0556766	1.35768852	1.39944592	87.3685481	109.500123	153.2395	-30.971942	-0.20211461	0.20211461	
Sep-90	45	11852	110.1234974	90.1052315	1.22216541	1.29410012	85.0965825	109.246793	141.376287	-31.25279	-0.221061046	0.221061046	
Oct-90	46	11280	104.8087285	89.6662056	1.16887659	1.14684654	91.3886248	108.993463	124.998776	-20.190048	-0.161521963	0.161521963	
Nov-90	47	8721	81.03164196	89.2918334	0.9074922	0.91672553	88.3924792	108.740133	99.6848555	-18.653214	-0.187121839	0.187121839	
Dec-90	48	8423	78.26275889	89.3371297	0.87603843	0.78252551	100.013044	108.486803	84.8936913	-6.6309324	-0.078108659	0.078108659	
Jan-91	49	8623	80.12106967	89.390169	0.8963074	0.78265887	102.37036	108.233473	84.7098871	-4.5888174	-0.054170978	0.054170978	
Feb-91	50	8207	76.25578323	89.3425498	0.85352146	0.76603205	99.5464657	107.980143	82.7162503	-6.4604671	-0.078103965	0.078103965	
Mar-91	51	7756	72.0652924	89.7219549	0.80320689	0.78354813	91.9730256	107.726813	84.4091431	-12.343851	-0.146238313	0.146238313	
Apr-91	52	8602	79.92594704	89.7916416	0.8901268	0.91536735	87.3157063	107.473483	98.3777178	-18.451771	-0.187560468	0.187560468	
May-91	53	8815	81.90504803	90.1005858	0.90904013	0.92397342	88.6443764	107.220153	99.0685721	-17.163524	-0.173248929	0.173248929	
Jun-91	54	10358	96.24191577	90.6034911	1.06223187	1.12140979	85.822254	106.966823	119.953643	-23.711727	-0.197674087	0.197674087	
Jul-91	55	9561	88.83654728	90.2186659	0.98468035	1.16736676	76.0999458	106.713493	124.573785	-35.737238	-0.286876068	0.286876068	
Aug-91	56	13216	122.7971769	90.286804	1.3600789	1.39944592	87.7469968	106.460163	148.985241	-26.188064	-0.175776232	0.175776232	
Sep-91	57	12775	118.6996017	91.2283481	1.30112628	1.29410012	91.7236619	106.206833	137.442275	-18.742674	-0.136367603	0.136367603	
Oct-91	58	10537	97.90510393	94.7382326	1.0334276	1.14684654	85.3689663	105.953503	121.512409	-23.607305	-0.194278966	0.194278966	
Nov-91	59	10262	95.34992659	99.3522635	0.9597157	0.91672553	104.011423	105.700173	96.898047	-1.5481204	-0.015976797	0.015976797	
Dec-91	60	8181	76.01420283	104.174967	0.7296782	0.78252551	97.1395838	105.446843	82.5148454	-6.5006426	-0.078781491	0.078781491	
Jan-92	61	7871	73.13382111	108.61091	0.67335612	0.78265887	93.4427812	105.193513	82.3306358	-9.1968147	-0.111705863	0.111705863	
Feb-92	62	9135	84.87834529	110.612853	0.76734614	0.76603205	110.802603	104.940183	80.3875439	4.49080141	0.055864394	0.055864394	
Mar-92	63	9260	86.03978954	111.713515	0.77018246	0.78354813	109.807919	104.686853	82.0271885	4.01260108	0.04891794	0.04891794	
Apr-92	64	16164	150.188678	113.643061	1.32158248	0.91536735	164.074759	104.433524	95.5950381	54.5936398	0.571092819	0.571092819	
May-92	65	13171	122.379057	115.072411	1.06349607	0.92397342	132.448676	104.180194	96.2597303	26.1193268	0.271342198	0.271342198	
Jun-92	66	18459	171.5127943	115.1541	1.48941979	1.12140979	152.943907	103.926864	116.544602	54.9681921	0.471649404	0.471649404	
Jul-92	67	12918	120.0282939	115.624484	1.03808717	1.16736676	102.819695	103.673534	121.025037	-0.9967433	-0.008235844	0.008235844	
Aug-92	68	15030	139.6520558	115.687202	1.20715216	1.39944592	99.7909627	103.420204	144.730982	-5.0789265	-0.035092186	0.035092186	
Sep-92	69	13804	128.2606107	115.269857	1.11269862	1.29410012	99.1118144	103.166874	133.508263	-5.2476527	-0.039305827	0.039305827	
Oct-92	70	14492	134.6531998	112.571822	1.19615369	1.14684654	117.411698	102.913544	118.026042	16.6271578	0.140877026	0.140877026	
Nov-92	71	9999	92.9062479	109.307776	0.84995095	0.91672553	101.345763	102.660214	94.1112385	-1.2049906	-0.012803897	0.012803897	
Dec-92	72	8655	80.4183994	105.733625	0.76057545	0.78252551	102.767767	102.406884	80.1359995	0.2823999	0.003524008	0.003524008	
Jan-93	73	8612	80.01886258	103.079338	0.77628421	0.78265887	102.23977	102.153554	79.9513846	0.06747802	0.000843988	0.000843988	
Feb-93	74	8556	79.49853556	103.985265	0.76451732	0.76603205	103.779647	101.900224	78.0588375	1.43969811	0.018443755	0.018443755	
Mar-93	75	8761	81.40330412	105.039469	0.77497825	0.78354813	103.890624	101.646894	79.6452339	1.75807027	0.022073766	0.022073766	

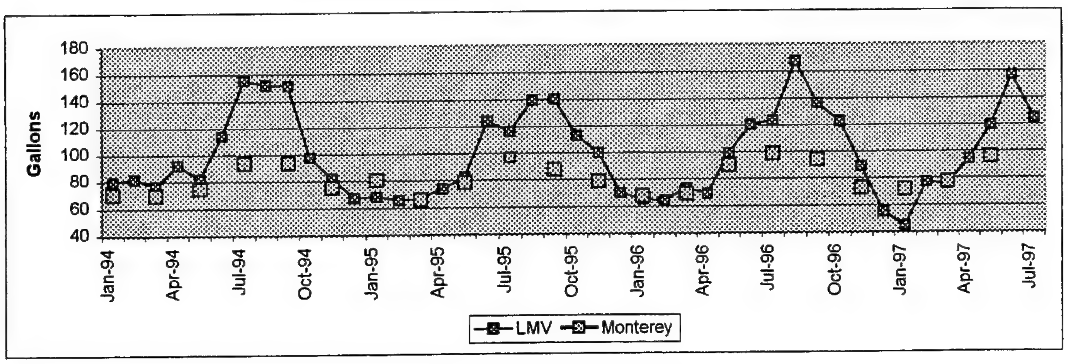
Apr-93	76	9694	90.07232395	104.941133	0.85831286	0.91536735	98.4001926	101.393564	92.8123584	-2.7400345	-0.029522302	0.029522302	
May-93	77	11210	104.1583197	105.002303	0.99196224	0.92397342	112.728696	101.140234	93.4508884	10.7074313	0.114578165	0.114578165	
Jun-93	78	11188	103.9539055	105.485076	0.98548448	1.12140979	92.6993028	100.886904	113.135562	-9.1816562	-0.081156235	0.081156235	
Jul-93	79	13333	123.8842888	105.492432	1.1743429	1.16736676	106.122851	100.633574	117.476289	6.40799928	0.054547171	0.054547171	
Aug-93	80	16955	157.5382972	105.595026	1.4919102	1.39944592	112.571908	100.380244	140.476723	17.0615738	0.12145481	0.12145481	
Sep-93	81	14602	135.6752707	105.490883	1.28613266	1.29410012	104.841402	100.126914	129.574251	6.10101933	0.047085121	0.047085121	
Oct-93	82	13440	124.878485	105.37319	1.18510681	1.14684654	108.888574	99.8735842	114.539675	10.3388101	0.090264008	0.090264008	
Nov-93	83	11209	104.1490282	104.539273	0.996267	0.91672553	113.609827	99.6202543	91.32443	12.8245982	0.140428998	0.140428998	
Dec-93	84	8692	80.7621869	104.029012	0.77634292	0.78252551	103.207097	99.3669243	77.7571536	3.00503329	0.03864639	0.03864639	
Jan-94	85	8594	79.85161461	105.764597	0.7549938	0.78265887	102.026078	99.1135944	77.5721333	2.27948132	0.029385312	0.029385312	
Feb-94	86	8839	82.12804533	106.832739	0.76875353	0.76603205	107.212283	98.8602644	75.730131	6.3979143	0.084483075	0.084483075	
Mar-94	87	8209	76.27436634	107.241954	0.71123626	0.78354813	97.3448385	98.6069344	77.2632792	-0.9889129	-0.012799261	0.012799261	
Apr-94	88	9942	92.37662933	106.776215	0.86514238	0.91536735	100.917548	98.3536045	90.0296787	2.34695062	0.026068633	0.026068633	
May-94	89	8808	81.84000715	104.741365	0.78135326	0.92397342	88.5739838	98.1002745	90.6420466	-8.8020395	-0.097107687	0.097107687	
Jun-94	90	12272	114.02595	103.270589	1.10414738	1.12140979	101.680894	97.8469446	109.726521	4.2994286	0.03918313	0.03918313	
Jul-94	91	16732	155.4662806	102.216385	1.52095264	1.16736676	133.176895	97.5936146	113.927542	41.5387389	0.364606646	0.364606646	
Aug-94	92	16315	151.5917026	101.032873	1.50041959	1.39944592	108.322658	97.3402846	136.222464	15.3692382	0.11282455	0.11282455	
Sep-94	93	16299	151.4430378	99.9407285	1.51532854	1.29410012	117.025751	97.0869547	125.640239	25.8027984	0.205370497	0.205370497	
Oct-94	94	10540	97.93297859	98.7688313	0.99153728	1.14684654	85.3932718	96.8336247	111.053308	-13.120329	-0.118144425	0.118144425	
Nov-94	95	8853	82.25812708	98.0320885	0.8390939	0.91672553	89.730377	96.5802948	88.5376215	-6.2794944	-0.070924589	0.070924589	
Dec-94	96	7249	67.35447455	98.4738245	0.68398353	0.78252551	86.0731992	96.3269648	75.3783077	-8.0238332	-0.10644751	0.10644751	
Jan-95	97	7314	67.95842556	97.2473393	0.69882041	0.78265887	86.8301997	96.0736348	75.192882	-7.2344565	-0.096211985	0.096211985	
Feb-95	98	7062	65.61695397	95.1091205	0.68991232	0.76603205	85.6582358	95.8203049	73.4014246	-7.7844706	-0.1060534	0.1060534	
Mar-95	99	7165	66.57398402	94.1377659	0.70719741	0.78354813	84.9647665	95.5669749	74.8813246	-8.3073406	-0.110940086	0.110940086	
Apr-95	100	7959	73.95147785	94.299981	0.78421519	0.91536735	80.7888522	95.313645	87.246999	-13.295521	-0.152389438	0.152389438	
May-95	101	8888	82.58333147	95.6805511	0.86311513	0.92397342	89.3784705	95.060315	87.8332048	-5.2498733	-0.059770941	0.059770941	
Jun-95	102	13333	123.8842888	96.5315025	1.28335606	1.12140979	110.471917	94.806985	106.317481	17.5668077	0.165229721	0.165229721	
Jul-95	103	12503	116.172299	96.5074994	1.20376447	1.16736676	99.5165383	94.5536551	110.378794	5.79350492	0.052487482	0.052487482	
Aug-95	104	15021	139.5684318	96.3212811	1.44898853	1.39944592	99.7312076	94.3003251	131.968205	7.60022636	0.057591344	0.057591344	
Sep-95	105	15084	140.1537997	96.5392455	1.45178056	1.29410012	108.30213	94.0469951	121.706227	18.4475723	0.151574596	0.151574596	
Oct-95	106	12174	113.1153777	96.605835	1.17089592	1.14684654	98.6316594	93.7936652	107.566941	5.54843697	0.051581247	0.051581247	
Nov-95	107	10785	100.2094093	97.0800914	1.03223439	0.91672553	109.312337	93.5403352	85.750813	14.4585963	0.168611769	0.168611769	
Dec-95	108	7515	69.8260279	97.6240344	0.71525448	0.78252551	89.2316309	93.2870053	72.9994618	-3.1734339	-0.043472018	0.043472018	
Jan-96	109	6986	64.91079587	97.7715378	0.66390278	0.78265887	82.9362558	93.0336753	72.8136307	-7.9028349	-0.108535103	0.108535103	
Feb-96	110	6909	64.19534621	99.2291504	0.6469404	0.76603205	83.8024286	92.7803453	71.0727182	-6.877372	-0.096765287	0.096765287	
Mar-96	111	7881	73.22673665	100.222572	0.73064116	0.78354813	93.455314	92.5270154	72.49937	0.72736662	0.01003273	0.01003273	
Apr-96	112	7415	68.89687251	100.449054	0.68588871	0.91536735	75.2669103	92.2736854	84.4643193	-15.567447	-0.184307965	0.184307965	
May-96	113	10657	99.0200904	100.377819	0.98647382	0.92397342	107.167682	92.0203555	85.024363	13.9957274	0.164608436	0.164608436	
Jun-96	114	12969	120.5021631	99.2686395	1.21389961	1.12140979	107.455958	91.7670255	102.908441	17.5937224	0.170964814	0.170964814	
Jul-96	115	13248	123.0945067			1.16736676	105.446301	91.5136955	106.830046	16.2644603	0.152246122	0.152246122	
Aug-96	116	18041	167.6289247			1.39944592	119.782352	91.2603656	127.713946	39.9149782	0.312534217	0.312534217	
Sep-96	117	14630	135.9354342			1.29410012	105.04244	91.0070356	117.772215	18.1632188	0.154223292	0.154223292	
Oct-96	118	13213	122.7693023			1.14684654	107.049459	90.7537057	104.080574	18.6887286	0.1795602	0.1795602	
Nov-96	119	9562	88.84583883			0.91672553	96.9165103	90.5003757	82.9640045	5.88183433	0.07089622	0.07089622	
Dec-96	120	5873	54.56929632			0.78252551	69.7348461	90.2470457	70.6206159	-16.05132	-0.227289431	0.227289431	
Jan-97	121	4779	44.40433631			0.78265887		89.9937158	70.4343795				MAPE
Feb-97	122	8302	77.13848086			0.76603205		89.7403858	68.7440117		Sum	17.5424454	0.146187045
Mar-97	123	8144	75.67041533			0.78354813		89.4870559	70.1174154				
Apr-97	124	10111	93.94690195			0.91536735		89.2337259	81.6816396				
May-97	125	12841	119.3128442			0.92397342		88.9803959	82.2155212				
Jun-97	126	16888	156.915763			1.12140979		88.727066	99.4994003				
Jul-97	127	13395	124.4603651			1.16736676		88.473736	103.281299				
Aug-97	128		0			1.39944592		88.2204061	123.459688				
Sep-97	129		0			1.29410012		87.9670761	113.838203				
Oct-97	130		0			1.14684654		87.7137461	100.594207				
Nov-97	131		0			0.91672553		87.4604162	80.177196				
Dec-97	132		0			0.78252551		87.2070862	68.24177				

Seasonality Calculations

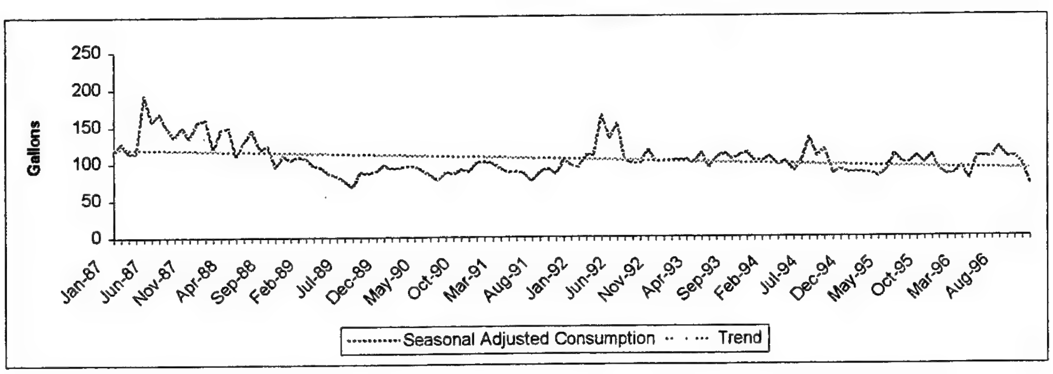
Month/Year	87	88	89	90	91	92	93	94	95	96	Med Avg	Adj Avg
Jan		0.88474062	0.817881288	0.84195267	0.8963074	0.67335612	0.77628421	0.7549938	0.69882041	0.66390278	0.777986475	0.782658865
Feb		0.85972624	0.831482135	0.81676529	0.85352146	0.76734614	0.76451732	0.76875353	0.68991232	0.6469404	0.761458921	0.76603205
Mar		0.8368936	0.815343399	0.85060189	0.80320689	0.77018246	0.77497825	0.71123626	0.70719741	0.73064116	0.778870433	0.783548132
Apr		1.02075591	0.956388735	0.97954276	0.8901268	1.32158246	0.85831286	0.86514238	0.78421519	0.68588871	0.909902709	0.915367354
May		0.77751338	0.893542697	0.94011523	0.90904013	1.06349607	0.99196224	0.78135326	0.86311513	0.98647382	0.918457402	0.923973425
Jun		1.14379513	1.049501468	1.04641438	1.06223187	1.48941879	0.98548448	1.10414738	1.28335606	1.21389961	1.114715092	1.121409789
Jul	1.34055537	1.36862929	1.017164699	1.01058201	0.98468035	1.03808717	1.1743429	1.52095264	1.20376447		1.160397706	1.167366761
Aug	1.41289695	1.375804	1.101188743	1.35768852	1.3600789	1.20719216	1.4919102	1.50041959	1.44898853		1.39109138	1.399445922
Sep	1.18275827	1.34488478	1.316970395	1.22215541	1.30112628	1.11269862	1.28613266	1.51532854	1.45178056		1.286374478	1.294100117
Oct	1.14169306	0.94774763	1.143289517	1.16887659	1.0334276	1.19615369	1.18510681	0.99153728	1.17089592		1.139999993	1.146846544
Nov	0.83432343	0.89865713	0.951304941	0.9074922	0.9597157	0.84995089	0.996267	0.8390939	1.03223439		0.911252772	0.916725526
Dec	0.85123498	0.74663461	0.877723624	0.87603843	0.7296782	0.76057545	0.77634292	0.68398353	0.71525448		0.777853921	0.782525515
											11.92836128	12



Gallons
250
200
150
100
50
0
Jan-87
Jul-87
Jan-88
Jul-88
Jan-89
Jul-89
Jan-90
Jul-90
Jan-91
Jul-91
Jan-92
Jul-92
Jan-93
Jul-93
Jan-94
Jul-94
Jan-95
Jul-95
Jan-96
Jul-96
Jan-97
Jul-97
Gal/person



Gallons
180
160
140
120
100
80
60
40
Jan-94
Apr-94
Jul-94
Oct-94
Jan-95
Apr-95
Jul-95
Oct-95
Jan-96
Apr-96
Jul-96
Oct-96
Jan-97
Apr-97
Jul-97
LMV
Monterey



Gallons
250
200
150
100
50
0
Jan-87
Jun-87
Nov-87
Apr-88
Sep-88
Feb-89
Jul-89
Dec-89
May-90
Oct-90
Mar-91
Aug-91
Jan-92
Jun-92
Nov-92
Apr-93
Sep-93
Feb-94
Jul-94
Dec-94
May-95
Oct-95
Mar-96
Aug-96
Seasonal Adjusted Consumption
Trend

APPENDIX E. WATER SAVINGS UNDER WA CONCEPT

Water Costs under WA concept

Month	Monterey	LMV	Difference(gal)	Monthly water use	Cost Savings	Cost saving per month	Total Costs Savings Per Month
	(Daily)	(Daily)	(Daily)	(LMV)	Per person per day ($)	Per person per month ($)	(2672 Avg residents)
Jan-97	74.2606482	59.7470478	-14.51360047	1792.411433	($0.05)	($1.58)	($4,210.76)
Feb-97	74.2606482	58.0566514	-16.2039968	1741.699543	($0.06)	($1.59)	($4,246.23)
Mar-97	67.6237224	65.3828929	-2.240829533	1961.486787	($0.01)	($0.24)	($650.12)
Apr-97	67.6237224	61.2043741	-6.41934837	1836.131222	($0.02)	($0.67)	($1,802.34)
May-97	84.6788594	87.7767859	3.097926492	2633.303576	$0.01	$0.34	$898.79
Jun-97	84.6788594	107.705695	23.02683593	3231.17086	$0.08	$2.42	$6,465.16
Jul-97	97.8017241	106.501485	8.699760605	3195.044541	$0.03	$0.94	$2,524.02
Aug-97	97.8017241	127.83029	30.0285659	3834.9087	$0.11	$3.26	$8,712.04
Sep-97	93.1728809	127.708824	34.53594304	3831.264718	$0.12	$3.63	$9,696.53
Oct-97	93.1728809	102.703613	9.530732331	3081.108396	$0.03	$1.03	$2,765.11
Nov-97	78.7550095	90.279602	11.5245925	2708.388061	$0.04	$1.21	$3,235.72
Dec-97	78.7550095	62.375226	-16.37978356	1871.256779	($0.06)	($1.78)	($4,752.19)
Average	82.7154741	88.1060406	5.390566505	2643.181218	$0.02	$0.56	$1,552.98

Total Yearly Savings (Per Person)	$6.97
Total Yearly Savings	$18,635.72

Water chages are calculated by determining the baseline usage rate for Montery city and subtracting LMV usage
The difference is mulplied by $2.6201 per 100 cubic feet or $.0035 per gallon of water delivered

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